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Aggregate Resources Inventory of the Town of Haldimand Regional Municipality of Haldimand-Norfolk Southern Ontario

By Staff of the Engineering and Terrain Geology Section, Ontario Geological Survey

1985

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The Mineral Resources Staff of Niagara District, Central Region, Simcoe District and Southwestern Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources and the Ministry of Northern Affairs and Mines do not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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Aggregate Resources Inventory of the Town of Haldimand Regional Municipality of Haldimand-Norfolk

by Staff[1] of the Engineering and Terrain Geology Section

1. Project Supervisors: Dale W. Scott and I. Szoke; field work and report by G. Jones; compilation and drafting by Staff of the Aggregate Assessment Office. The Mineral Resources Staff of Niagara District, Central Region, Simcoe District, and Southwestern Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

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Abstract

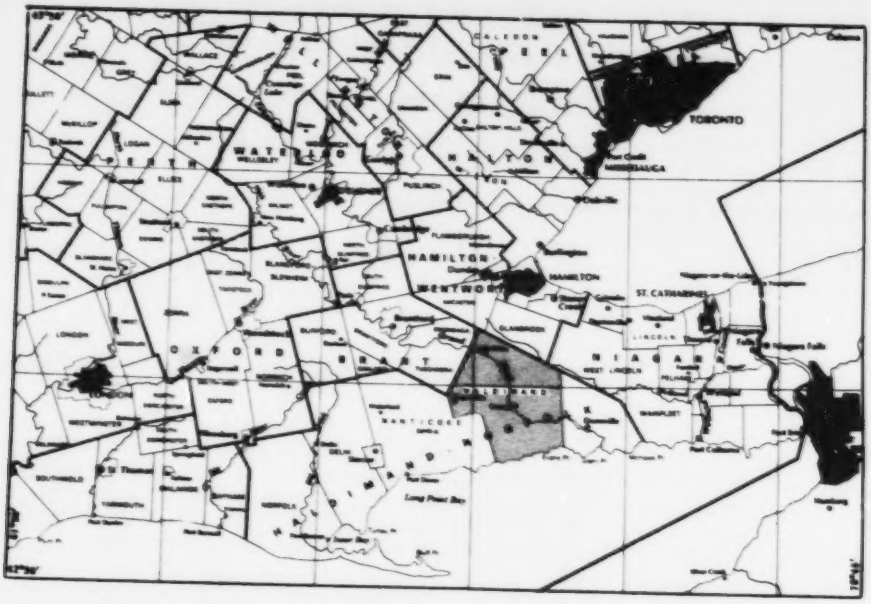


Figure 1. *Key map showing the Location of the Town of Haldimand, Scale 1:1 800 000.*

This report includes both an inventory and evaluation of sand and gravel as well as bedrock resources in the Town of Haldimand. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under the Pits and Quarries Control Act.

The Town of Haldimand has only limited surficial granular resources. The existing deposits are limited in both thickness and areal extent and have not been selected for resource protection. They may, however, be capable of supplying small amounts of aggregate to meet local demands within the town. Approximately 1340 acres (540 ha) are occupied by sand and gravel deposits in the town and they contain estimated granular resources of 21 million tons (19 million tonnes). Further investigation, especially concerning the presence of buried aggregate may increase the total resource potential.

Presently, the Town of Haldimand relies on bedrock-derived aggregate and sand and gravel from sources outside the town to meet most of its aggregate needs. The town is underlain by bedrock of the Guelph, Salina, Bertie, Oriskany, Bois Blanc, Onondaga and Dundee Formations. Of these, the Bertie Formation is the best suited for extractive development. Two areas have been selected for possible bedrock resource protection. An estimated 7000 acres (2850 ha) are currently available for extraction, containing possible resources of 1400 million tons (1270 million tonnes).

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Introduction

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1982, the total tonnage of mineral aggregates extracted was 101 million tons (92 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1983).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand and gravel resources as well as a discussion on the potential of bedrock-derived aggregate. The most recent information available has been used to prepare the report. As new information becomes available, revisions may be necessary.

Part I — Inventory Methods

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods include the examination of natural and man-made exposures of granular material. Most observations are made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites include estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations are also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing, hand augering and geophysical techniques are used to assess subsurface materials. Airphotos at various scales are used to determine the continuity of deposits, especially in areas where information is limited.

Deposits with potential for further extractive development or those where existing data are scarce, are studied in greater detail. Representative layers in these deposits are sampled in 25- to 100-pound (11 to 45 kg) units from existing pit faces or from test pits. The samples are analysed for grain size distribution and in some cases Los Angeles abrasion, absorption, and Magnesium Sulphate soundness tests along with petrographic analyses are performed.

Analyses are performed either in the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications, or in the Geoscience Laboratories, Geoservices Section, Ontario Geological Survey. In areas of limited subsurface exposure, test holes are drilled and geophysical surveys using hammer seismic equipment are undertaken. The symbols for and locations of sample and test hole sites along with geophysical traverse lines are noted on Map 1.

In the office, the field data are supplemented by pit information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under the Pits and Quarries Control Act are obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above-named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, are used in some areas to corroborate thickness estimates or to indicate the presence of buried granular material. These records are used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable because of the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted (e.g. wayside and abandoned pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography

maps, and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated quarriable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of 60 feet (18 m) is used for thickness. Volume estimates are then multiplied by the density factor (the estimated weight in tons of a one-foot (0. 3 m) thick section of rock, one acre (0.4 ha) in extent).

Resources of dolostone are calculated using a density factor of 165 pounds per cubic foot (2649 kg per cubic metre) or 3600 tons per acre (8070 tonnes per hectare). Sandstone resources are calculated using a density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) and shale resources are calculated with a factor of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel deposits are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

Part II — Data Presentation and Interpretation

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources" shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

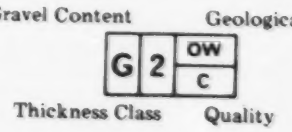
Map 1 is derived from existing surficial geology maps of the area or from airphoto interpretation in areas where surficial mapping is incomplete. The map shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

On the map, all sand and gravel deposits are outlined and shaded. The present level of extractive activity is also indicated. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are identified by a numbered dot on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Map 1. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the deposit contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The information from which these symbols are derived has been plotted in grain size distribution graphs. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol. Geophysics lines are shown on the map by a line symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by dark shading on Map 2.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by light shading on Map 2. Such deposits are believed

to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resources in the report area, they may contain large quanitities of sand and gravel and should be considered as part of the aggregate supply of the area.

Areas of tertiary significance are outlined on the map by a solid line but have no shading. They are not considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single, land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

Deposit Size

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m), and containing more than 35 percent gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

Aggregate Quality

The limitations of natural aggregates for various uses result from variations in the litholgy of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indicates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of a deposit. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock types determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of both the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes, pits or sample sites have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B and C; Hot-Laid Asphaltic Sand Nos. 1,2,3,4, and 8; and concrete sand. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

Location and Setting

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the

basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalites with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, drift thickness and bedrock topography maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources) and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of these areas of thin drift are shown by three levels of shading. The darkest shade indicates where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas consitute potential resource areas because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these zones also represent potential resource ares. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas, the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. Those areas which are licenced for extraction under the Pits and Quarries Control Act are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, licenced acreage and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected drill hole which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics and uses of the bedrock units found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource are usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting

criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approch. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas, if present, are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Part III — Assessment of Aggregate Resources in the Town of Haldimand

LOCATION AND POPULATION

The Town of Haldimand occupies an area of 154,774 acres (62 637 ha) in the eastern part of the Regional Municipality of Haldimand-Norfolk. The town was formed during the incorporation of the regional municipality in 1974, and includes the former townships of North Cayuga, Oneida, Rainham, Seneca and South Cayuga. Haldimand is shown on parts of the Brantford (40 P/1), Dunnville (30 L/13), Grimsby (30 M/4) and Simcoe (40 I/16) map sheets of the National Topographic System at a scale of 1:50 000.

The population of the Town of Haldimand was 16 626 in 1982, an increase of 9 percent since 1973 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). Population centres in the town include Caledonia, Cayuga and York located along the banks of the Grand River as well as Hagersville at the town's western boundary. Outside these communities, the majority of the residents are engaged in farming or are rural-residential inhabitants. There are also cottage settlements along the shore of Lake Erie. The Six Nations and New Credit Indian Reserves are located along the town's northwestern boundary between Hagersville and the Grand River.

Access within the town is provided by municipal roads, paved regional roads and King's Highways 3, 6, 54 and 56. Haldimand is also served by lines of Conrail and the Canadian National Railways.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of unconsolidated sediments, including sand and gravel deposits, are predominantly the result of glacial activity which took place during the Late Wisconsinan Substage of the Pleistocene Epoch, informally known as the 'Great Ice Age'. This substage, which lasted from approximately 23 000 to 10 000 years ago, was marked by the repeated advance and melting back of massive, continental ice sheets.

The Town of Haldimand is included in the physiographic region referred to as the Haldimand Clay Plain (Chapman and Putnam 1984). The plain slopes gently southward from the Niagara Escarpment to Lake Erie, in the Niagara Peninsula, and is composed predominantly of glaciolacustrine clay and silt. The clay and silt were deposited in the deep waters of proglacial lakes which covered the area as the ice retreated.

In certain parts of the plain, localized areas of till are present at the surface. The Wentworth Till (Karrow 1963), the oldest surficial sediment present in the area, is exposed in several drumlins which protrude through the glaciolacustrine sediments (Feenstra 1974). The drumlins are most abundant in the central part of the town and were deposited by the Ontario-Erie glacial lobe which advanced in a southwesterly direction (Feenstra 1974). The younger Halton Till (Karrow 1963) is also exposed in the area. Four small deposits of this clay to clayey silt till are situated in the southeastern part of the town. Till has little value as an aggregate.

During lowering of the glacial lakes which covered the area, several small beach deposits were formed on drumlins and bedrock rises in the town. Some of these deposits have supplied small amounts of sand and gravel for local use within the town.

South and west of the Grand River, sand and gravel has been observed buried beneath glaciolacustrine clay and silt in several pits. Although information pertaining to the environment in which the sand and gravel was deposited is lacking, some of the pits expose irregularly bedded material of probable ice-contact origin. The buried aggregate has been used locally for road-building and construction purposes.

The postglacial deposition of alluvium along the banks of the Grand River and its tributaries, along with the recent development of beaches and dunes along Lake Erie, have also influenced the physiography of the area.

EXTRACTIVE ACTIVITY

Several quarries have been opened in the Town of Haldimand. The quarries are developed in bedrock of the Bertie, Oriskany, Bois Blanc, Onondaga and Dundee Formations in the west-central and southern parts of the town. At the time of writing, five quarry properties were licenced to operate having a total area of 1222.8 acres (494.9 ha).

The sand and gravel pits developed in the town include two licenced properties having a total area of 111.8 acres (45.2 ha) and thirteen identified unlicenced sources. The pits are generally small operations, opened to supply aggregate for local use within the town. Since the Town of Haldimand has a limited supply of sand and gravel, it relies on bedrock-derived aggregate and sand and gravel brought in from other areas to meet most of its needs. There is, however, a significant need for locally produced sand and gravel as the costs of importing natural aggregate are usually higher. This natural aggregate is often imported in the form of ready-mixed concrete.

The town was designated in 1974 under the Pits and Quarries Control Act. Since the designation of the town, production figures for the licenced properties have been maintained by the Niagara District Office of the Ontario Ministry of Natural Resources. The average annual production from both pits and quarries in the seven-year period between 1974 and 1980 has been approximately 1.3 million tons (1.2 million tonnes). The majority of this production has been from the licenced quarries.

The town is also the site for two gypsum mines. The mines, operated by Domtar Construction Division and the Canadian Gypsum Company Limited, are located near Caledonia and north of Hagersville, respectively. The gypsum, extracted from rock of the Salina Formation, is used mainly in the manufacture of wallboard, plaster and cement.

SELECTED SAND AND GRAVEL RESOURCE AREAS

The identified sand and gravel deposits in the Town of Haldimand are limited in respect to both thickness and areal extent. Because of their limited available resources, the deposits have not been selected for possible resource protection at the primary or secondary levels of significance. They have been selected, however, at the tertiary level and may be capable of meeting some local aggregate needs including blending sand for use with crushed stone. Although these deposits are not the 'best' resources, they should be considered as part of the town's aggregate supply. Approximately 1340 acres (540 ha) are occupied by sand and gravel deposits in the town and contain resources of 21 million tons (19 million tonnes).

SAND AND GRAVEL RESOURCES OF TERTIARY SIGNIFICANCE

Nine small glaciolacustrine beach deposits have been selected at the tertiary level. The beach deposits generally consist of coarse sand and fine gravel and one pit (pit no. 6) has been developed in this material. Other beach deposits observed in the town were very restricted in size, and too small to delineate on Map 1. Pit no. 11 was developed in one of these beaches, exposing up to 25 feet (8 m) of sandy fine gravel on the flank of a drumlin. Faces in pit no. 9, however, exposed only 2 to 4 feet (0.6 to 1.2 m) of similar material. Gradations performed on samples of the beach material indicate the unprocessed aggregate may be suitable for some granular base course products (pit 9a, b and sample site HD-SS-1; Figures 3 and 6).

In the past, some extractive activity has occurred in alluvial deposits along the banks of the Grand River. Presently, most of the pits developed in these deposits are overgrown or rehabilitated and are not shown on Map 1. Small amounts of sandy aggregate, which may be acceptable for Granular Base Course B and fill (Deike 1981a), are available from these deposits.

Perhaps the greatest potential for finding significant quantities of suitable aggregate lies in the location of buried deposits within the town. These deposits are often associated with small mounds or ridges and are clay covered (Feenstra, in prep. c). Ten pits have been developed in these deposits. Faces in the pits generally range from 10 to 30 feet (3 to 9 m) high with clay overburden usually between 3 and 10 feet (1 and 3 m) thick. The sand and gravel exposed in the pits ranges from uniformly bedded sand to irregularly bedded sand and gravel. Pit nos. 13 and 15 are predominantly sand sources, while pockets of gravel are present in pit nos. 1, 3, 4, 5, 7, 12 and 14. Material extracted from pit nos. 1 and 12 is generally suitable for granular base course (Deike 1981a). Gradations performed on samples from the pits indicate a wide range in aggregate suitability (Figures 2a, 2b, 3, 4, 5 and 6). In addition to the pits, water well information indicates the presence of buried sand and gravel at several locations within the town. Detailed subsurface investigation, however, would be required to determine the extent and quality of buried aggregate resources within the town.

BEDROCK GEOLOGY

The Town of Haldimand is underlain by bedrock deposited during Upper Silurian to Middle Devonian time. The Silurian age bedrock includes the Guelph, Salina and Bertie Formations and the rocks of the Devonian period include the Oriskany, Bois Blanc, Onondaga and Dundee Formations. Drift overlying the bedrock is generally thinnest in the southern and west-central parts of the town. A number of quarries have been developed in this area and bedrock is exposed in several outcrops.

The Guelph Formation underlies the northwestern corner of the town. It consists of massive, light brown dolostone which may be suitable for the production of dolomitic lime. However, the formation is covered by drift exceeding 25 feet (8 m) and has not been selected for possible resource protection.

The Guelph Formation is overlain by the argillaceous dolostone and shale of the Salina Formation (Telford and Tarrant 1975). Gypsum and other evaporitic materials are also present in the Salina strata. The formation is mined for gypsum near Caledonia and north of Hagersville, but has little value as aggregate.

South and west of the Grand River, a west- to northwest-trending ridge known as the Onondaga Escarpment is a prominent physiographic feature. It was produced by differential erosion between the resistant dolostones of the Bertie Formation and the weaker underlying Salina rocks. A variety of lithologies are present in the Bertie Formation including bituminous, argillaceous, mottled and finely laminated dolostone (Telford and Hamblin 1980; Telford and Tarrant 1975). The formation is suitable for the production of a range of construction and road-building products. However, layers of very argillaceous dolostone may be unsuitable for some aggregate uses because of poor durability (Hewitt 1960).

During Early Devonian time the region was above sea level and the upper surface of the Bertie Formation was subject to erosion. Sandstone of the Oriskany Formation, which was subsequently deposited over the Bertie Formation when the sea level rose, was also subjected to erosion and in many areas was completely eroded away. In the Town of Haldimand, surface exposure of this massive quartzose sandstone is restricted to an area located between Clanbrassil and Nelles Corners.

Following the deposition and partial erosion of the Oriskany Formation, the Bois Blanc Formation was deposited. In areas where the Oriskany sandstone survived the erosional processes, the Bois Blanc limestone overlies the sandstone. But, where the Oriskany sandstone has been completely removed by erosion, the Bois Blanc Formation directly overlies the Bertie dolostone. The Bois Blanc strata consist of brownish grey, cherty, medium- to thin-bedded limestone (Telford and Hamblin 1980; Telford and Tarrant 1975). The formation is commonly fossiliferous and contains shale partings and minor dolostone. At the base of the formation, a thin glauconitic sandstone unit is often present.

The overlying Onondaga Formation is a medium- to massive-bedded, fossiliferous limestone which is

variably cherty. Both the Bois Blanc and Onondaga Formations have been quarried for crushed stone but their chert content makes much of the material unsuitable for concrete and asphaltic aggregate without beneficiation.

The youngest bedrock which underlies the town is the Dundee Formation. It is a medium-bedded, fine-grained, fossiliferous limestone which in this area contains minor amounts of chert (Telford and Tarrant 1975). The formation has been extracted for crushed stone at several quarries in southern Ontario.

SELECTED BEDROCK RESOURCE AREAS

Two areas have been selected for possible bedrock resource protection in the Town of Haldimand. They are located in the west-central part of the town in areas where the bedrock is overlain by less than 25 feet (8 m) of overburden. The formations selected for resource protection include the Bertie, Bois Blanc and Oriskany Formations. Of these, the chert-free Bertie dolostone is considered the most desirable for extractive development, as a wide range of products can be produced from it. The cherty Bois Blanc dolostone is generally suitable for lower specification aggregate uses while the Oriskany sandstone is not well suited for aggregate use. The latter two formations have been selected for possible resource protection because they form only a thin layer over the more desirable Bertie dolostone.

The Selected Bedrock Resource Areas occupy a total available area of 7000 acres (2850 ha) and contain resources of approximately 1400 million tons (1270 million tonnes). The areas are readily accessible by road and are near rail transportation. Bedrock resources within the cultural constraint boundary surrounding Hagersville have not been selected for resource protection because of competing land uses within the boundary.

Several quarries within the Town of Haldimand have also been developed in the Onondaga and Dundee Formations. Similar to the Bois Blanc Formation, the Onondaga limestone is acceptable for the production of granular base course and railway ballast. It is not suitable for concrete or asphaltic aggregate without beneficiation because of its chert content. The formation has not been selected for resource protection, however, as the combined thickness of the Onondaga and Bois Blanc strata limits the economic viability of extracting the underlying higher quality Bertie dolostone. Also, significant resources of similar quality rock are available from the Bois Blanc limestone which has been selected for resource protection.

The Dundee limestone in the town contains little chert and is considered to be of higher quality than the cherty Onondaga Formation. West of the report area, in the City of Nanticoke, the Dundee Formation thickness and the chert content increases. Deike (1981b) reports that chert-free sections of Dundee limestone in a quarry located within the City of Nanticoke are generally suitable for granular base course, asphaltic and concrete aggregate. Similar products may be produced from the formation in the town, but because the formation only thinly overlies the Onondaga strata it has not been selected for resource protection.

SELECTED BEDROCK RESOURCE AREA 1

Selected Bedrock Resource Area 1 consists of Bertie dolostone which is overlain by less than 25 feet (8 m) of drift. Three unlicenced quarries with faces ranging from 15 to 25 feet (5 to 8 m) high have been developed in the Area. The Bertie Formation has also been extracted from beneath the Bois Blanc and Oriskany Formations in Selected Bedrock Resource Area 2 to produce a wide range of aggregate products. Deike (1981a) reports that crushed stone from this formation is generally suitable for road base, sub-base and hot-laid uses.

Resource Area 1 occupies 4100 acres (1660 ha), exclusive of licenced areas. Cultural constraints and previous extraction reduce the area currently available to 3200 acres (1300 ha). Assuming a workable thickness of 50 feet (15 m), available bedrock resources are estimated to total 580 million tons (530 million tonnes).

SELECTED BEDROCK RESOURCE AREA 2

Three areas, labelled 2a, 2b and 2c on Map 3, make up Selected Bedrock Resource Area 2. Less than 25 feet (8 m) of drift overlies the bedrock in these areas. The bedrock surface in Area 2a and 2b consists of Bois Blanc limestone while in Area 2c it consists of the Oriskany sandstone. Since the Bois Blanc and Oriskany Formations average about 25 feet (8 m) and 10 feet (3 m), respectively, it is also possible to extract the underlying Bertie dolostone, resulting in a 60 foot (18 m) workable thickness estimate for the Area. Area 2a includes a narrow band of bedrock located east of Hagersville, along with two small outliers of Bois Blanc limestone that are surrounded by the Bertie dolostone of Selected Bedrock Resource Area 1a.

Three licenced properties and two unlicenced quarries have been developed in Resource Area 2. Extraction of bedrock in quarry no. 5 has been undertaken in both Areas 2b and 2c. Faces in the quarry range from 40 to 60 feet (12 to 18 m) high. In Area 2c, up to 10 feet (3 m) of Oriskany sandstone overlies the Bertie dolostone in the quarry. In the southern part of the quarry, the sandstone is overlain by approximately 5 feet (1.5 m) of Bois Blanc strata. Further south in the quarry the sandstone unit pinches out and up to 15 feet (5 m) of Bois Blanc limestone directly overlies 25 to 30 feet (8 to 9 m) of Bertie dolostone.

Faces in the main quarry of licenced property no. 4 range in height from 50 to 60 feet (15 to 18 m). The Bertie dolostone exposed in the quarry is overlain by up to 7 feet (2 m) of Oriskany sandstone and 3 to 5 feet (1 to 1.5 m) of cherty Bois Blanc limestone. A small sandstone quarry, also located within the licenced property, exposed a minimum of 12 feet (4 m) of the Oriskany Formation (Telford and Tarrant 1975).

In quarry nos. 4 and 5, the faces are worked primarily for Bertie dolostone. A wide range of crushed stone products are produced from the quarries. The dolostone is acceptable for uses including

granular base course, 16 mm Crushed A and B and some hot-laid asphaltic stone products. Blending sand is required for the production of hot-laid asphaltic aggregate and sections of very argillaceous dolostone may be unsuitable for high-specification aggregate products.

The sandstone in the quarries is generally not well suited for aggregate use and poses minor extraction and processing problems. However, it has been extracted for use as building stone, armour stone and for silica sand in the production of glass and foundry sand (Hewitt 1963). In addition, the Ontario Ministry of Transportation and Communications reports the Oriskany Formation is acceptable for use as rip-rap and well cemented varieties of the stone may be suitable for Hot-Laid No. 1 asphaltic aggregate. The thinness of the formation and possible contamination by the overlying cherty Bois Blanc limestone upon extraction inhibits the economic viability of quarrying the sandstone for asphaltic aggregate.

Extraction of the Bois Blanc Formation and underlying Bertie dolostone has also occurred within the cultural constraint boundary surrounding the community of Hagersville. Here, two licenced properties (quarry nos. 2 and 3) and one unlicenced quarry (quarry no. 6) have been developed. Faces in quarry no. 2 range from 50 to 60 feet (15 to 18 m) high exposing approximately 25 feet (8 m) of Bois Blanc limestone over the Bertie dolostone. Products derived from the Bertie dolostone in the quarry include concrete aggregate and agricultural limestone while granular base course is produced from the Bois Blanc strata. Similar quality bedrock to that exposed in quarry nos. 2, 4 and 5 is expected to exist in the presently undeveloped parts of Resource Area 2.

The total extent of Bedrock Resource Area 2 is 4500 acres (1820 ha), exclusive of licenced areas. An estimated 3800 acres (1540 ha) are currently available for extraction, containing crushed stone resources of approximately 820 million tons (740 million tonnes).

SUMMARY

The sand and gravel deposits in the Town of Haldimand are the product of both glacial activity which occurred during the Late Wisconsinan and the postglacial deposition of alluvium and dune sand. These deposits are limited in thickness and areal extent, and therefore, have not been selected for resource protection at the primary or secondary levels of significance. The deposits, however, may be able to supply small quantities of aggregate to meet some local needs in the town. Additional quantities of aggregate may also be available from buried sand and gravel deposits.

Since the town has low available resources of quality sand and gravel, it relies on bedrock-derived aggregate and imported sand and gravel to meet most of its needs. Two areas in the town have been selected for possible bedrock resource protection. The bedrock in these areas consists of the Bertie, Oriskany and Bois Blanc formations. Of these, the Bertie dolostone is best suited for aggregate use.

Enquiries regarding the Aggregate Resources Inventory for the Town of Haldimand should be directed to the following offices: the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines, Room M1B-45, Macdonald Block, Queen's Park, Ontario, M7A 1W3 (Tel. (416) 965-1663); or for the part of the town covered by the former townships of Walpole and Rainham contact the Simcoe District Office, Ontario Ministry of Natural Resources, 645 Norfolk St. N., Simcoe, Ontario, N3Y 3R2 (Tel. (519) 426-7650) or the Southwestern Region Geological Office, Ontario Ministry of Natural Resources, 458 Central Ave., London, Ontario N6B 2E5, (Tel. (519) 433-8431); for the remainder of the town contact the Niagara District Office, Ontario Ministry of Natural Resources, Highway 20, Box 1070, Fonthill, Ontario, L0S 1E0 (Tel. (416) 892-2656) or the Central Region Office, Ontario Ministry of Natural Resources, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9 (Tel. (416) 884-9203).

TABLE 1. TOTAL SAND AND GRAVEL RESOURCES, TOWN OF HALDIMAND*.

1 Class No.	2 Deposit Type (see Appendix C)	3 Areal Extent Acres (Hectares)	4 Original Tonnage Millions of Tons (Tonnes)
2	G-IC	16 (6)	<1 (<1)
	S-IC	35 (14)	1 (1)
	S-WD	8 (3)	<1 (<1)
3	S-AL	1190 (480)	18 (16)
	G-LB	55 (22)	1 (1)
	S-WD	39 (16)	1 (1)
		1340 (540)	21 (19)

N.B. Minor variations in all tables are caused by rounding of data.

*Identified deposits within the Six Nations and New Credit Indian Reserves, and cultural constraint boundary surrounding Hagersville have been omitted on all tables.

TABLE 2. SAND AND GRAVEL PITS, TOWN OF HALDIMAND.

1 No.	2 MTC No.	3 Owner/ Operator	4 Lot	5 Con.	6 Licenced Areas Acres (Hectares)	7 Face Height Feet (Metres)	8 % Gravel
LICENCED PITS							
1	G8-15	Peart	14	4	103.0 (41.7)	30 (9)	variable
2	D5-12	E. Norrington	18	3	8.8 (3.6)	11-13 (3-4)	10-20 buried; additional material may be available beneath water table
					111.8 (45.2)		
UNLICENCED PITS*							
3	-	unknown	Ardross Blk.			10-30 (3-9)	20 variable; buried
4	-	unknown	15	5		12 (4)	10-20 variable
5	-	unknown	15,16	4		-	rehabilitated
6	-	unknown	18,19	Range E of Plank Road		-	overgrown
7	-	unknown	Dennis Block			20 (6)	predominantly sand with some gravel layers; buried
8	-	unknown	66	River Range		6 (2)	till
9	-	unknown	40	1		2-4 (0.6-1.2)	5-40
10	-	unknown	27	4		5-15 (1.5-5)	variable
11	-	Lewis	24	3		20-25 (6-8)	25-45
12	D5-24	A. Elgersma	21,22	3		15-20 (5-6)	30-50 buried
13	-	unknown	1	8		10 (3)	sand; buried
14	-	unknown	35	2		-	-
15	-	unknown	Fradenburg Tract			20-30 (6-9)	overgrown

*Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 3. SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWN OF HALDIMAND.

1 Deposit No.	2 Unlicenced Area Acres (Hectares)	3 Cultural Setbacks Acres (Hectares)	4 Extracted Area Acres (Hectares)	5 Available Area Acres (Hectares)	6 Estimated Deposit Thickness Feet (Metres)	7 Available Aggregate Millions of Tons (Tonnes)
			- NONE -			

TABLE 4. TOTAL IDENTIFIED BEDROCK RESOURCES, TOWN OF HALDIMAND.

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
3-25 (1-8)	Dundee	20 (6)	2600 (1050)	187 (70)
25-50 (8-15)	Dundee	20 (6)	115 (46)	8 (7)
			2700 (1090)	195 (177)
0-3 (0-1)	Onondaga	60 (18)	1170 (475)	255 (231)
3-25 (1-8)	Onondaga	60 (18)	32,500 (13,200)	7000 (6400)
25-50 (8-15)	Onondaga	60 (18)	5500 (2230)	1190 (1080)
			39,000 (15,800)	8400 (7600)
0-3 (0-1)	Bois Blanc	25 (8)	870 (350)	78 (71)
3-25 (1-8)	Bois Blanc	25 (8)	4700 (1900)	425 (385)
25-50 (8-15)	Bois Blanc	25 (8)	1270 (510)	114 (103)
			6800 (2750)	620 (560)
0-3 (0-1)	Oriskany	10 (3)	980 (395)	31 (28)
3-25 (1-8)	Oriskany	10 (3)	500 (202)	16 (14)
25-50 (8-15)	Oriskany	10 (3)	220 (89)	7 (6)
			1700 (690)	54 (49)
0-3 (0-1)	Bertie	50 (15)	1080 (435)	194 (176)
3-25 (1-8)	Bertie	50 (15)	4200 (1700)	760 (690)
25-50 (8-15)	Bertie	50 (15)	4200 (1700)	760 (690)
			9500 (3850)	1710 (1550)
3-25 (1-8)	Salina	60 (18)	3350 (1360)	660 (600)
25-50 (8-15)	Salina	60 (18)	33,000 (13,400)	6500 (5900)
			36,500 (14,800)	7200 (6500)
25-50 (8-15)	Guelph	60 (18)	315 (127)	68 (62)
			97,000 (39,500)	18,200 (16,500)

TABLE 5. QUARRIES, TOWN OF HALDIMAND.

1 NO.	2 MTC NO.	3 OWNER/ OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
LICENCED QUARRIES						
1	S06-015	Standard Aggregates	14	13	31.8 (12.9)	water filled
2	-	Standard Aggregates	Pts. W1/2 28,29	Range E of Plank Road	129.0 (52.2)	50-60 (15-18)
3	-	Standard Aggregates	Pts. E1/2 28,29	Range E of Plank Road	103.0 (41.7)	unopened
4	DO5-028	Nelson Aggregate Co.	S1/2 47,48,49, 50,51	1	500.0 (202.4)	50-60 (15-18)
5	DO5-020	Cayuga Materials & Construction Company Ltd.	Pts. of 44,45,46,47	1N	459.0 (185.8)	40-60 (12-18)
					1222.8 (494.9)	
UNLICENCED QUARRIES*						
6	SO6-017	Standard Aggregates	28	Range E of Plank Road		50-60 (15-18)
7	DO5-004	Lewis	24	3		20-25 (6-8)
8	DO5-011	Leonard quarry	25	3		15-20 (5-6)
9	-	unknown	40	1N		15 (5)
10	-	unknown	48	15		water filled
11	-	unknown	49	15		water filled
12	-	unknown	2	3		10 (3)
13	-	unknown	2	2		5 (1.5)
14	-	unknown	2	2		10-12 (3-4)
15	-	unknown	31	4		water filled
16	-	unknown	31	4		20 (6)
17	-	unknown	19	6		6-9 (2-3) partially water filled
18	-	unknown	14	5		10 (3)

*Abandoned quarries or wayside quarries operating on demand under authority of a permit.

TABLE 6. SELECTED BEDROCK RESOURCE AREAS, TOWN OF HALDIMAND.

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
1	0-25 (0-8)	4100 (1660)	890 (360)	10 (4)	3200 (1300)	50 (15)	580 (530)
2a	0-25 (0-8)	2380 (960)	320 (130)	0 (0)	2060 (830)	60* (18)	445 (405)
2b	0-25 (0-8)	1430 (580)	280 (113)	10 (4)	1140 (460)	60* (18)	246 (223)
2c	0-25 (0-8)	700 (285)	100 (40)	0 (0)	600 (243)	60** (18)	127 (115)
		4500 (1820)	700 (285)	10 (4)	3800 (1540)		820 (740)
		8600 (3500)	1590 (640)	20 (8)	7000 (2850)		1400 (1270)

* Workable thickness estimate in Areas 2a and 2b includes the Bois Blanc Formation and part of the underlying Bertie Formation.

**Workable thickness estimate in Area 2c includes both the Oriskany and Bertie Formations.

TABLE 7. SUMMARY OF TEST HOLE DATA, TOWN OF HALDIMAND.

Test Hole Number: HD-TH-1
Location: River Range, Lot 44
Elevation: Approx. 640 feet (195m) a.s.l.
Date: June 30, 1982

Depth Feet (metres)	**Description**
0-17 (0-5)	greyish brown **clay**

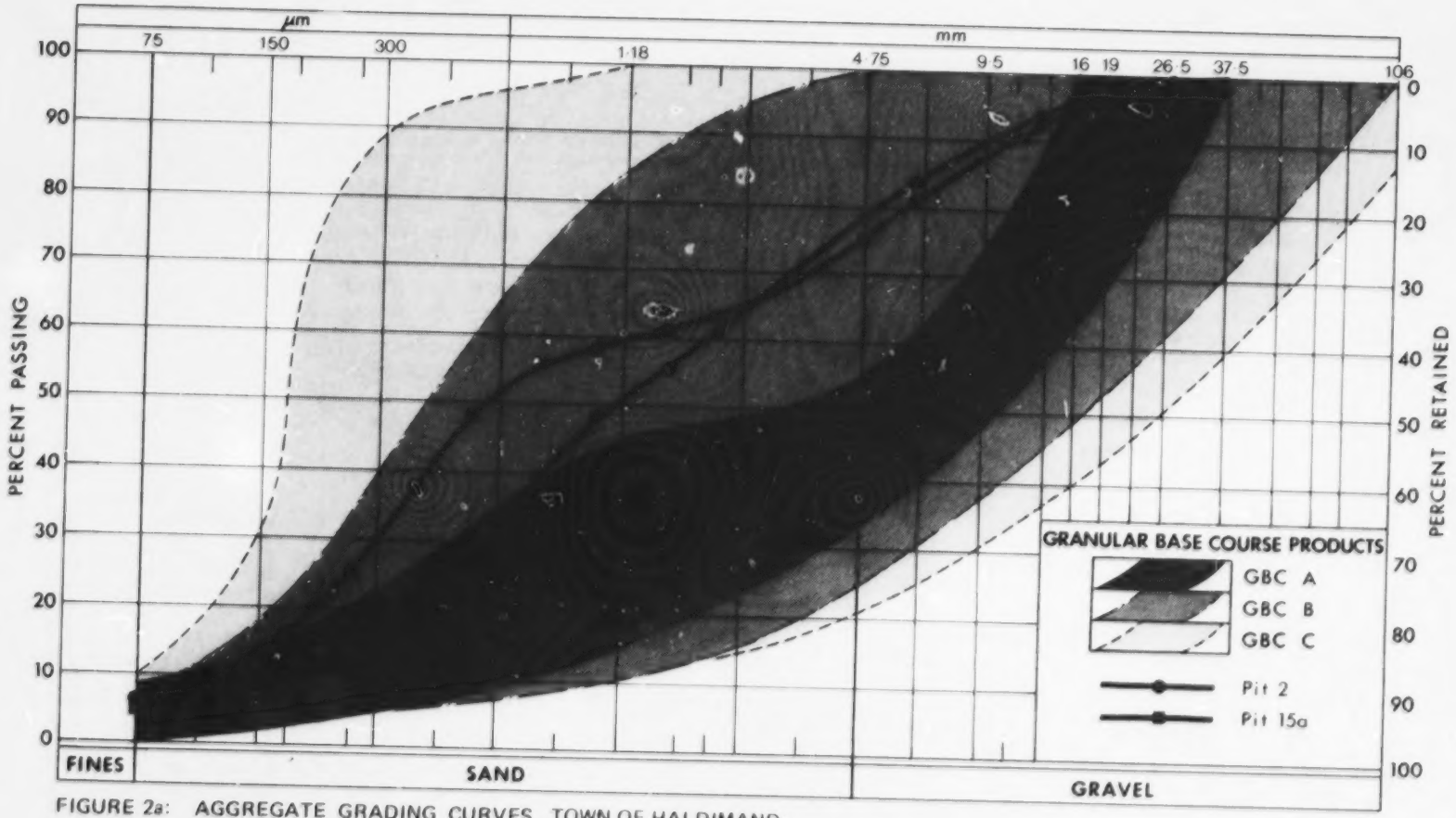


FIGURE 2a: AGGREGATE GRADING CURVES, TOWN OF HALDIMAND;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

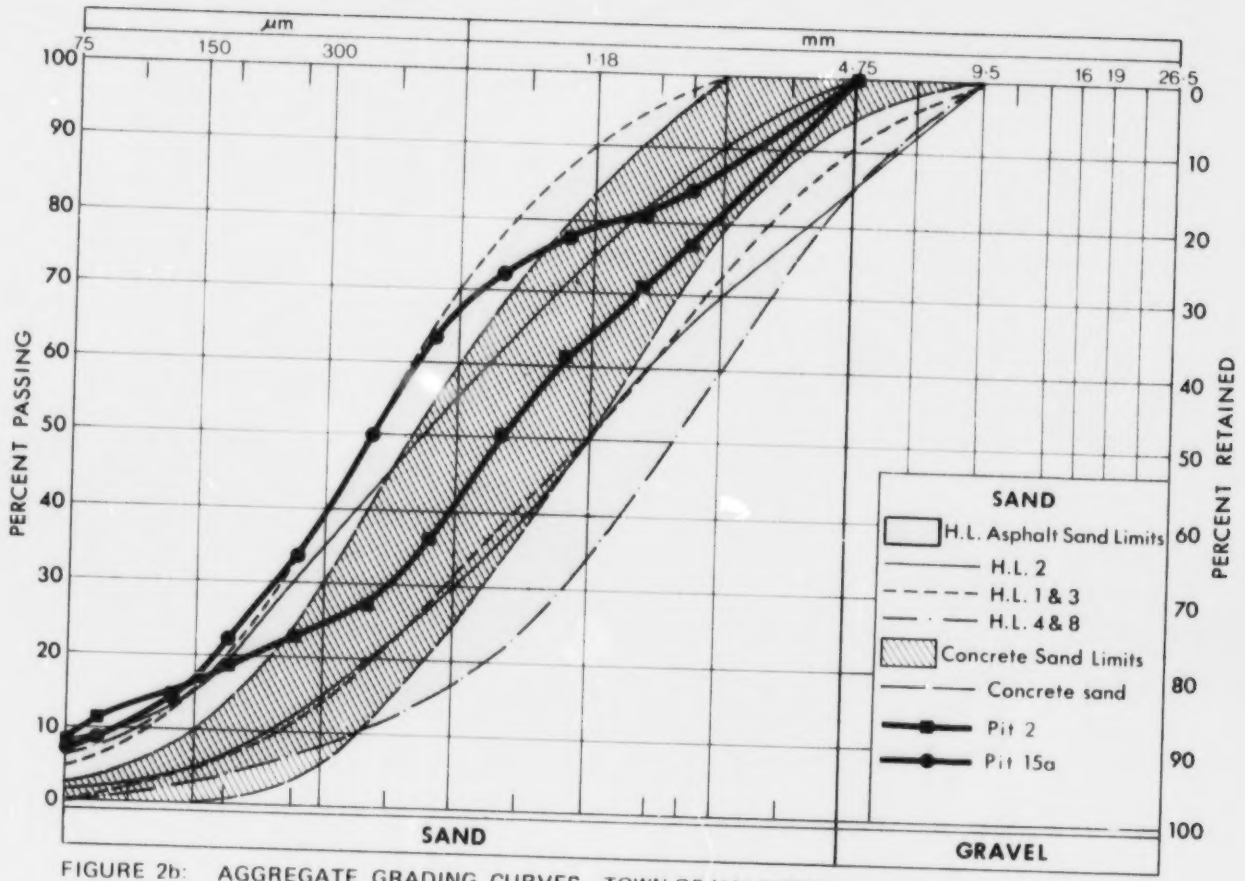


FIGURE 2b: AGGREGATE GRADING CURVES, TOWN OF HALDIMAND;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

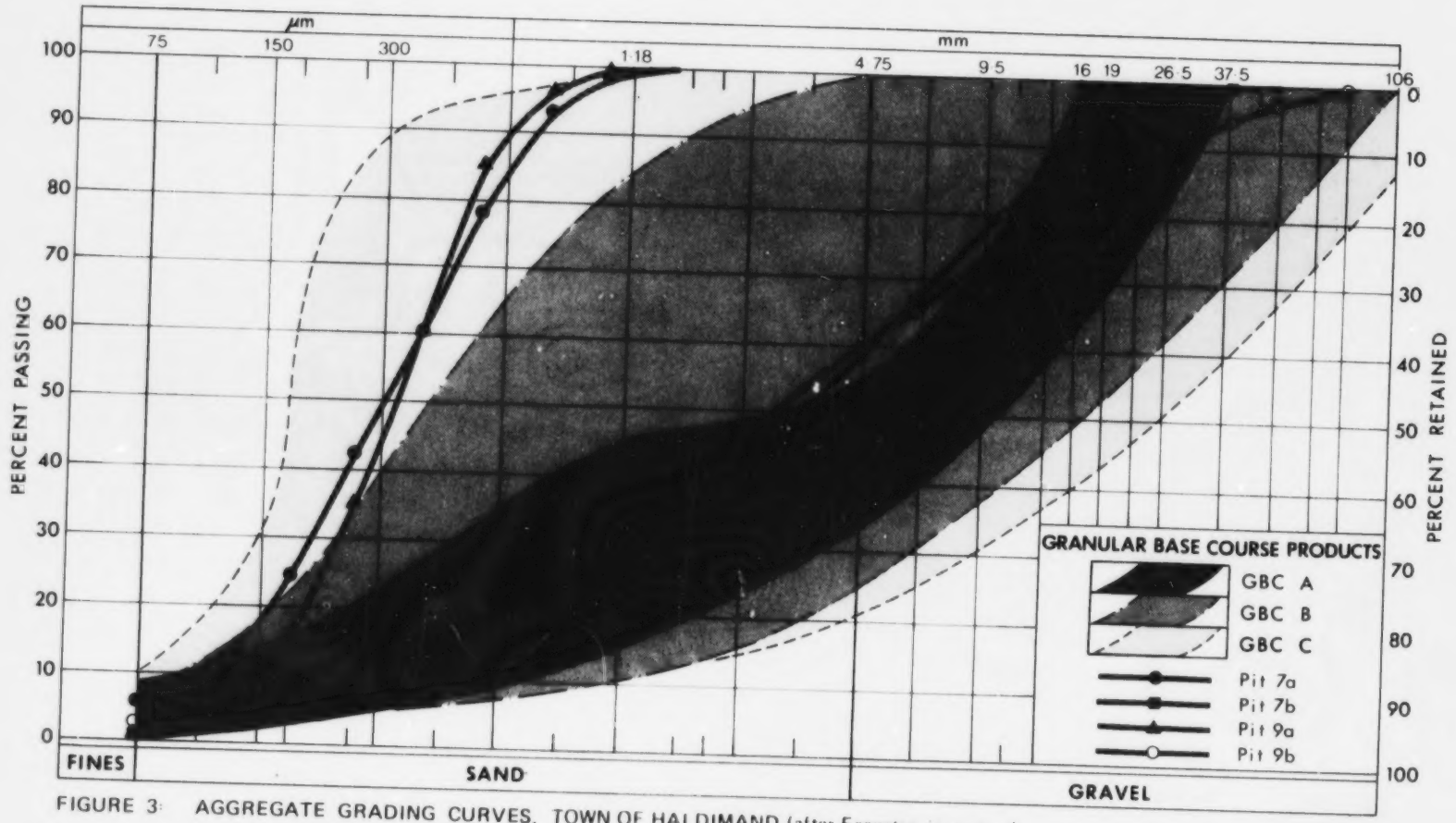


FIGURE 3: AGGREGATE GRADING CURVES, TOWN OF HALDIMAND (after Feenstra, in prep. c);

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

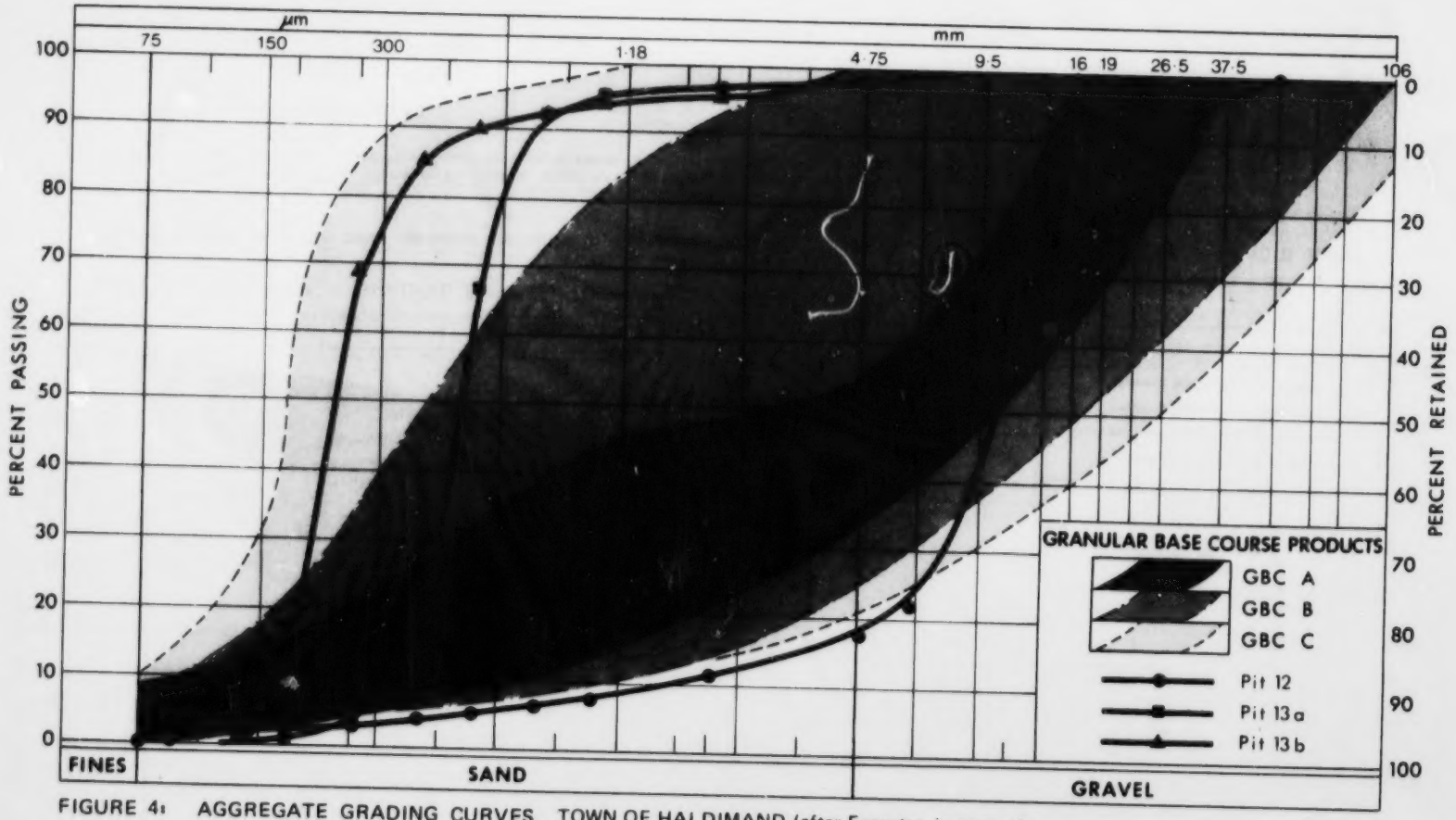


FIGURE 4: AGGREGATE GRADING CURVES, TOWN OF HALDIMAND (after Feenstra, in prep. c);

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

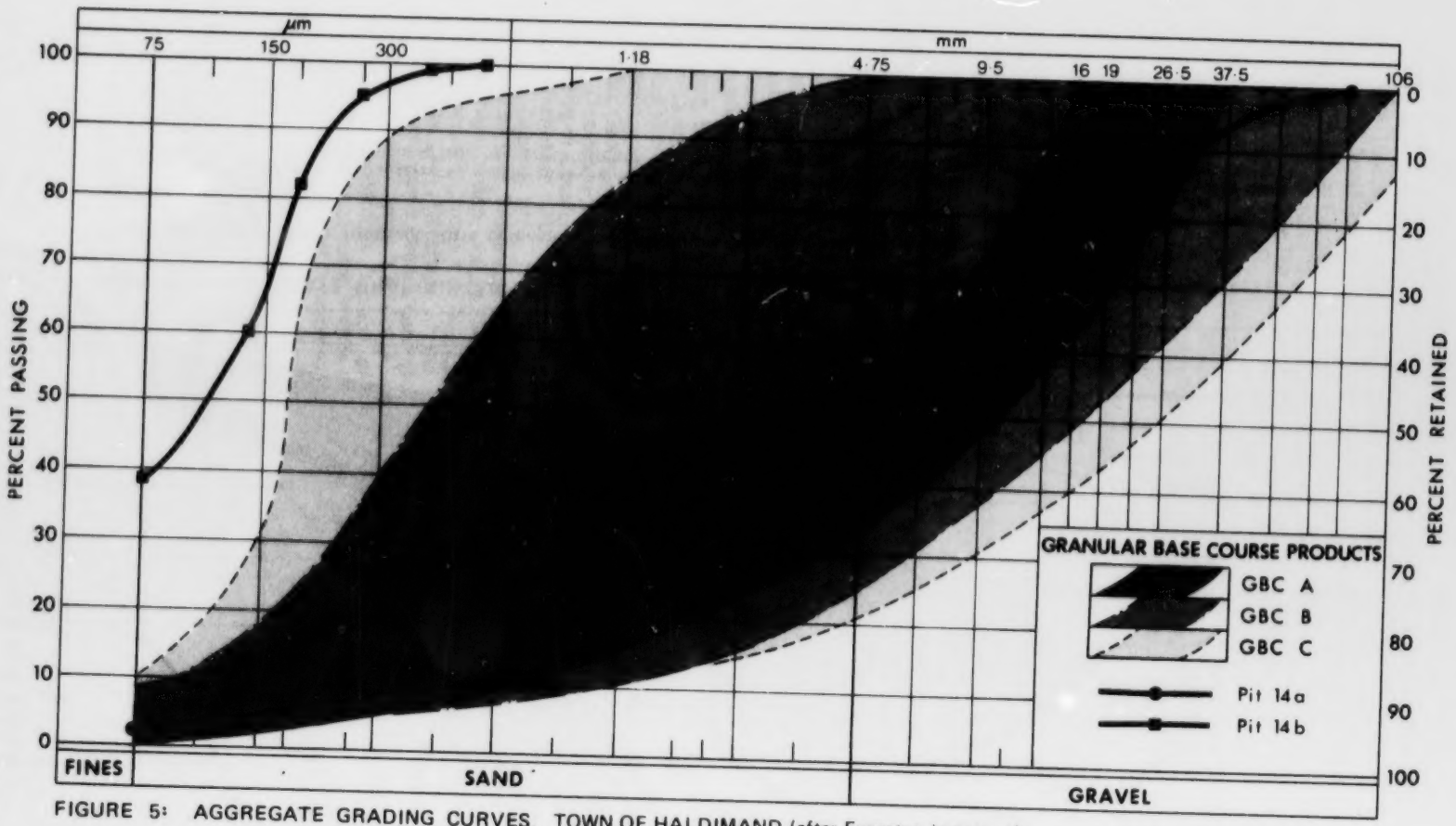


FIGURE 5: AGGREGATE GRADING CURVES, TOWN OF HALDIMAND (after Feenstra, in prep. c);

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

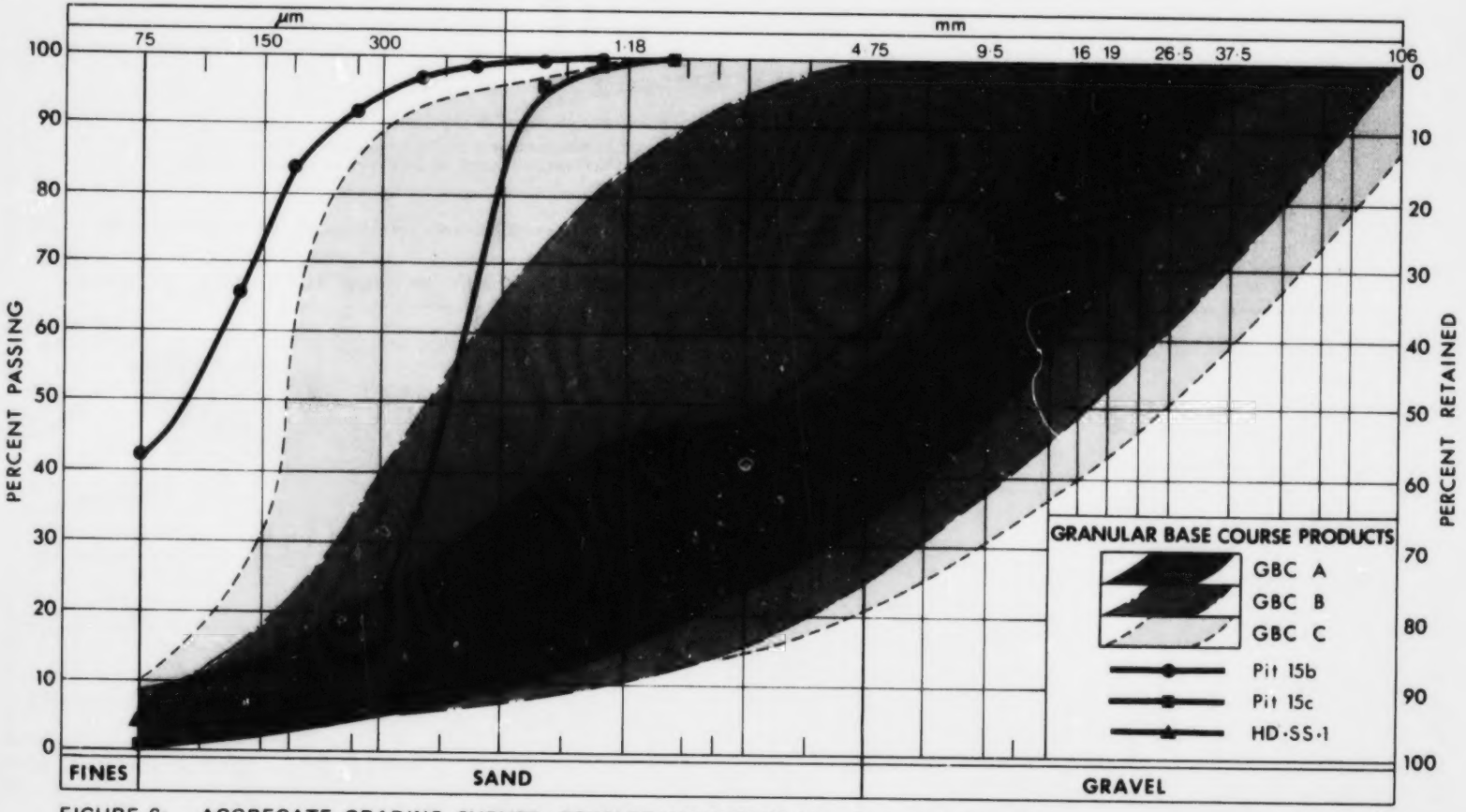


FIGURE 6: AGGREGATE GRADING CURVES, TOWN OF HALDIMAND (after Feenstra, in prep. c);

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

References

Association of Professional Engineers of Ontario
1976: Performance Standards for Professional Engineers Advising on and Reporting on Oil, Gas and Mineral Properties; Association of Professional Engineers of Ontario, 11 p.

Barnett, P.J. and Ferguson, A.J.
1976: Drift Thickness, Simcoe Area, Southern Ontario; Ontario Division of Mines, Colour Map 2371, scale 1:50 000.

Barnett, P.J., Girard, C.K. and Watt, A.K.
1976: Quaternary Geology, Simcoe Area, Southern Ontario; Ontario Division of Mines, Colour Map 2369, scale 1:50 000.

Chapman, L.J. and Putnam, D.F.
1984: The Physiography of Southern Ontario; Ontario Geological Survey, Special Volume 2, 270 p. Accompanied by Map P.2715 (coloured), scale 1:600 000.

Cowan, W.R.
1972: Pleistocene Geology of the Brantford Area, Southern Ontario; Ontario Department of Mines and Northern Affairs, Colour Map 2240, scale 1:63 360.

Deike, W.
1981a: Aggregate Suitability Evaluation, Town of Haldimand; Engineering and Materials Office, Ontario Ministry of Transportation and Communications, 6 p., unpublished report.
1981b: Aggregate Suitability Evaluation, City of Nanticoke, Regional Municipality of Haldimand-Norfolk; Aggregate Sources Research, 28 p., unpublished report.

Feenstra, B.H.
1974: Quaternary Geology of the Dunnville Area, Southern Ontario; Ontario Division of Mines, Preliminary Map P.981, Geological Series, scale 1:50 000. Geology 1973.
1975: Quaternary Geology of the Grimsby Area, Southern Ontario; Ontario Division of Mines, Preliminary Map P.993, Geological Series, scale 1:50 000. Geology 1974.
in prep. a: Drift Thickness of the Dunnville Area, Southern Ontario, Ontario Geological Survey, map in preparation, scale 1:50 000.
in prep. b: Drift Thickness of the Grimsby Area, Southern Ontario; Ontario Geological Survey, map in preparation, scale 1:50 000.
in prep. c: Quaternary Geology of the Dunnville-Grimsby Areas, Southern Ontario; Ontario Geological Survey, report in preparation.

Hewitt, D.F.
1960: The Limestone Industries of Ontario; Ontario Department of Mines, Industrial Mineral Circular 5, 177 p.
1963: Silica in Ontario; Ontario Department of Mines, Industrial Mineral Report 9, 36 p.

Karrow, P.F.
1963: Pleistocene Geology of the Hamilton-Galt Area; Ontario Department of Mines, Geological Report No. 16, 68 p.

Karrow, P.F. and Sprague, D.J.
1975: Bedrock Topography of the Brantford Area, Southern Ontario; Ontario Division of Mines, Preliminary Map P.1049, Bedrock Topography Series, scale 1:50 000.

Liberty, B.A., Feenstra, B.H. and Telford, P.G.
1976: Paleozoic Geology of the Grimsby Area, Southern Ontario; Ontario Division of Mines, Colour Map 2343, scale 1:50 000.

Ontario
1983: The Pits and Quarries Control Act, 1971; Revised Statutes of Ontario, 1980, Chapter 378, Queen's Printer for Ontario.

Ontario Interministerial Committee on National Standards and Specifications (Metric Committee)
1975: Metric Practice Guide; 67 p.

Ontario Ministry of Municipal Affairs and Housing
1983: Municipal Directory 1983; Queen's Printer for Ontario, 241 p.

Ontario Ministry of Natural Resources
1980: Statistics 1980; Ontario Ministry of Natural Resources, 122 p.

Ontario Ministry of Treasury, Economics and Intergovernmental Affairs
1974: 1974 Municipal Directory; Queen's Printer for Ontario, 128 p.

Robertson, J.A.
1975: Mineral Deposit Studies, Mineral Potential Evaluation, and Regional Planning in Ontario; Ontario Division of Mines, Miscellaneous Paper 61, 42 p.

Telford, P.G.
1979: Paleozoic Geology of the Brantford Area, Southern Ontario; Ontario Geological Survey, Preliminary Map P.1984, Geological Series, scale 1:50 000.

Telford, P.G. and Hamblin, A.P.
1980: Paleozoic Geology of the Simcoe Area, Southern Ontario; Ontario Geological Survey, Preliminary Map P.2234, Geological Series, scale 1:50 000.

Telford, P.G. and Tarrant, G.A.
1975: Paleozoic Geology of the Dunnville Area, Southern Ontario; Ontario Division of Mines, Preliminary Map P.988, Geological Series, scale 1:50 000.

Appendix A — Suggested Additional Reading

American Geological Institute
1972: Glossary of Geology; Washington, D.C., 858 p.

Bauer, A.M.
1970: A Guide to Site Development and Rehabilitation of Pits and Quarries; Ontario Department of Mines, Industrial Mineral Report 33, 62 p.

Cowan, W.R.
1977: Toward the Inventory of Ontario's Mineral Aggregates; Ontario Geological Survey, Miscellaneous Paper 73, 19 p.

Fairbridge, R.W. (ed.)
1968: The Encyclopedia of Geomorphology; Encyclopedia of Earth Sciences, Vol. III, Reinhold Book Corp., N.Y., 1295 p.

Flint, R.F.
1971: Glacial and Quaternary Geology; John Wiley and Sons Inc., 892 p.

Hewitt, D.F.
1960: The Limestone Industries of Ontario; Ontario Department of Mines, Industrial Mineral Circular 5, 177 p.
1964a: Building Stones of Ontario, Part I Introduction; Ontario Department of Mines, Industrial Mineral Report 14, 43 p.
1964b: Building Stones of Ontario, Part II Limestone; Ontario Department of Mines, Industrial Mineral Report 15, 43 p.
1964c: Building Stones of Ontario, Part III Marble; Ontario Department of Mines, Industrial Mineral Report 16, 89 p.
1964d: Building Stones of Ontario,. Part IV Sandstone; Ontario Department of Mines, Industrial Mineral Report 17, 57 p.
1972: Paleozoic Geology of Southern Ontario; Ontario Division of Mines, Geological Report 105, 18 p.

Hewitt, D.F. and Karrow, P.F.
1963: Sand and Gravel in Southern Ontario; Ontario Department of Mines, Industrial Mineral Report 11, 151 p.

Hewitt, D.F. and Vos, M.A.
1970: Urbanization and Rehabilitation of Pits and Quarries; Ontario Department of Mines, Industrial Mineral Report 34, 21 p.

Lowe, S.B.
1980: Trees and Shrubs for the Improvement and Rehabilitation of Pits and Quarries in Ontario; Ontario Ministry of Natural Resources, 71 p.

McLellan, A.G., Yundt, S.E. and Dorfman, M.L.
1979: Abandoned Pits and Quarries in Ontario; Ontario Geological Survey, Miscellaneous Paper 79, 36 p.

Ontario Mineral Aggregate Working Party
1977: A Policy for Mineral Aggregate Resource Management in Ontario; Ontario Ministry of Natural Resources, 232 p.

Ontario Ministry of Natural Resources
1975: Vegetation for the Rehabilitaion of Pits and Quarries; Forest Management Branch, Division of Forests, 38 p.

Peat, Marwick and Partners and M.M. Dillon Limited
1981: Mineral Aggregate Transportation Study; Industrial Mineral Background Paper 1, 133 p. Summary Report 26 p.

Proctor and Redfern Limited
1974: Mineral Aggregate Study, Central Ontario Planning Region; Prepared for the Ontario Ministry of Natural Resources, over 100 p.

Proctor and Redfern Limited and Gartner Lee Associates Limited
1975: Mineral Aggregate Study of Part of the Eastern Ontario Region; Prepared for the Ontario Ministry of Natural Resources, about 200 p.
1977: Mineral Aggregate Study and Geological Inventory, Southwestern Region of Ontario; Prepared for the Ontario Ministry of Natural Resources, about 200 p.

Appendix B — Glossary

Abrasion resistance: Tests such as the Los Angeles abrasion test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

Absorption capacity: Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

Aggregate: Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

Alkali-aggregate reaction: A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

Blending: Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

Cambrian: The first period of the Palezoic Era, thought to have covered the time between 570 and 500 million years ago. The Cambrian precedes the Ordovician Period.

Clast: An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of larger rock mass. Synonyms include particle and fragment.

Crushable aggregate: Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

Deleterious lithology: A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

Devonian: A period of the Paleozoic Era thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

Dolostone: A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

Drift: A general term for all unconsolidated rock debris transported from one place and deposited in another, distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

Drumlin: A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were formed beneath an advancing ice sheet, and were shaped by its flow.

Eolian: Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

Fines: A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

Glacial lobe: A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced then melted back numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

Gradation: The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

Granular base course: Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed

aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

Hot-laid (or asphaltic) aggregate: Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2 and 8) used to bind the surface course to the underlying granular base course.

Lithology: The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

Magnesium sulphate soundness test: This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

Meltwater channel: A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

Ordovician: an early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

Paleozoic Era: One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

Petrographic examination: An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

Pleistocene: An epoch of the recent geological past including the time from approximately 2 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

Possible resource: Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

Shale: A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

Silurian: An early period of the Palezoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

Soundness: The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

Till: Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

Wisconsinan: Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

Appendix C — Geology of Sand and Gravel Deposits

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

Ice-Contact Terraces (ICT): These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous because of extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive because of the variability of the deposits both in terms of quality and grain size distribution.

Kames (K): Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuties. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

Eskers (E): Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

Undifferentiated Ice-Contact Stratified Drift (IC): This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits because of their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

Outwash (OW): Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

Alluvium (AL): Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and they have generally low value because of the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

Glaciolacustrine Beach Deposits (LB): These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear de-

posits, so that extractive operations are often numerous and extensive.

Glaciolacustrine Deltas (LD): These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

Glaciolacustrine Plains (LP): The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources because of their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

End Moraines (EM): These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

Windblown Deposits (WD): Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consists of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

Appendix D — Geology of Bedrock Deposits

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

Bass Islands Formation (Upper Silurian)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18 m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunnville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate because of high soundness losses.

Bobcaygeon Formation (Middle Ordovician)

Composition: Compact, homogeneous, medium- to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

Bois Blanc Formation (Lower-Middle Devonian)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High cherty content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

Dundee Formation (Middle Devonian)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone. Used at St. Marys as raw material for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

Gull River Formation (Middle Ordovician)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

Lockport and Amabel Formations (Middle Silurian)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone.

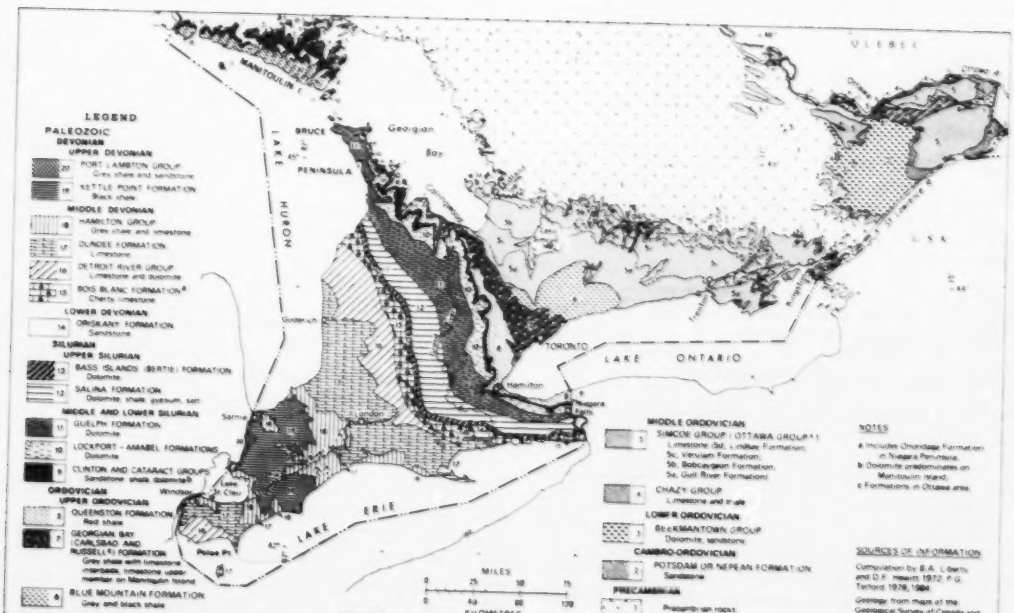


Figure 7. Bedrock Geology of Southern Ontario.

Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

Onondaga Formation (Middle Devonian)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey-brown, fine-grained, very cherty limestone having estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey-brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High cherty content makes much of the material unsuitable for concrete aggregate.

Ottawa Formation (Middle Ordovician)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings. 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of limestone for cement production and agricultural uses.

Oxford Formation (Lower Ordovician)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

Detroit River Group (Middle Devonian)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to microcrystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces much of Ontario's lime and cement. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for crushed stone.

Grenville Marble (Precambrian)

Composition: Recrystallized fine- to coarse-grained white limestone and dolostone, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

Guelph Formation (Middle Silurian)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. Thickness: 100 to 170 feet (30 to 52 m). Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

Lindsay Formation (Upper Ordovician)

Composition: fine-crystalline, rubbly, nodular-weathering limestone. Collingwood Member: organic-rich interbedded calcareous shales and limestones. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

Verulam Formation (Middle Ordovician)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for use in cement manufacture. The formation is unsuitable for crushed stone because of clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

Georgian Bay Formation (Upper Ordovician) (Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue-grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in the vicinity of Metro Toronto produce brick and structural tile. Lightweight aggregate has been produced at Streetsville by heat expansion of the shale.

Hamilton Group (Middle Devonian)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona Formation is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). The Arkona Formation has a thickness of 14 to 121 feet (4 to 37 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile.

Queenston Formation (Upper Ordovician)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

Nepean (Potsdam) Formation (Cambro-Ordovician)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

Salina Formation (Upper Silurian)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum. The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

Blue Mountain Formation (Upper Ordovician)

(Formerly known as the Whitby Formation) Composition: Blue-grey, predominantly non-calcareous shale. Uses: Quarried at Bowmanville for use in cement production.

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North Seneca

Caledonia

CLANBROOK TP

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RM OF HAMILTON-WENTWORTH

RM OF HALDIMAND-NORFOLK

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Willow Grove Sta

Willow Grove

McKENZIE

BOSTON

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Caledonia

North Seneca

Conserver

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Town Hall

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Pipeline

Gas

Elsie

Creek

Empire Corners

Sinclairville

Blackheath

Lork

Oswego

Creek

Willow Grove

HD TH 1

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RM OF HAMILTON-WENTWORTH
RM OF HALDIMAND-NORFOLK

TOWN OF HALDIMAND
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689±

714±

635

646

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85

23C
39T

60C

30C

43C

48C

78C

50C

40
150

3

Ministry of Northern Affairs and Mines

Ontario

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

THE TOWN OF HALDIMAND

REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 30 L/13, 30 M/4
40 I/16, 40 P/1

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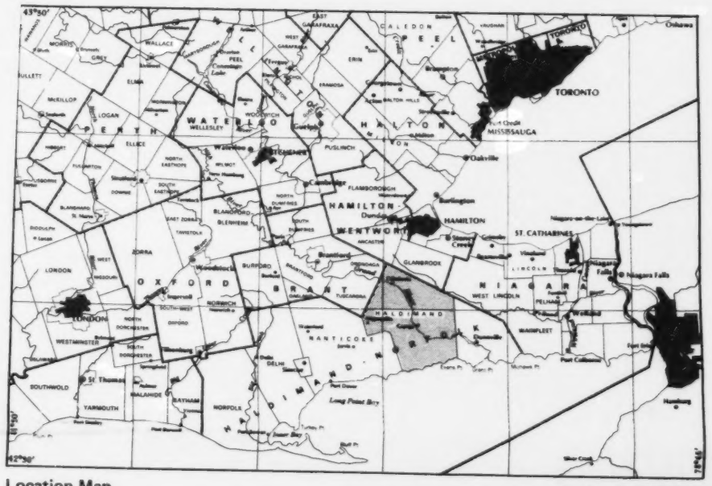


Location Map

Scale: 1:800,000

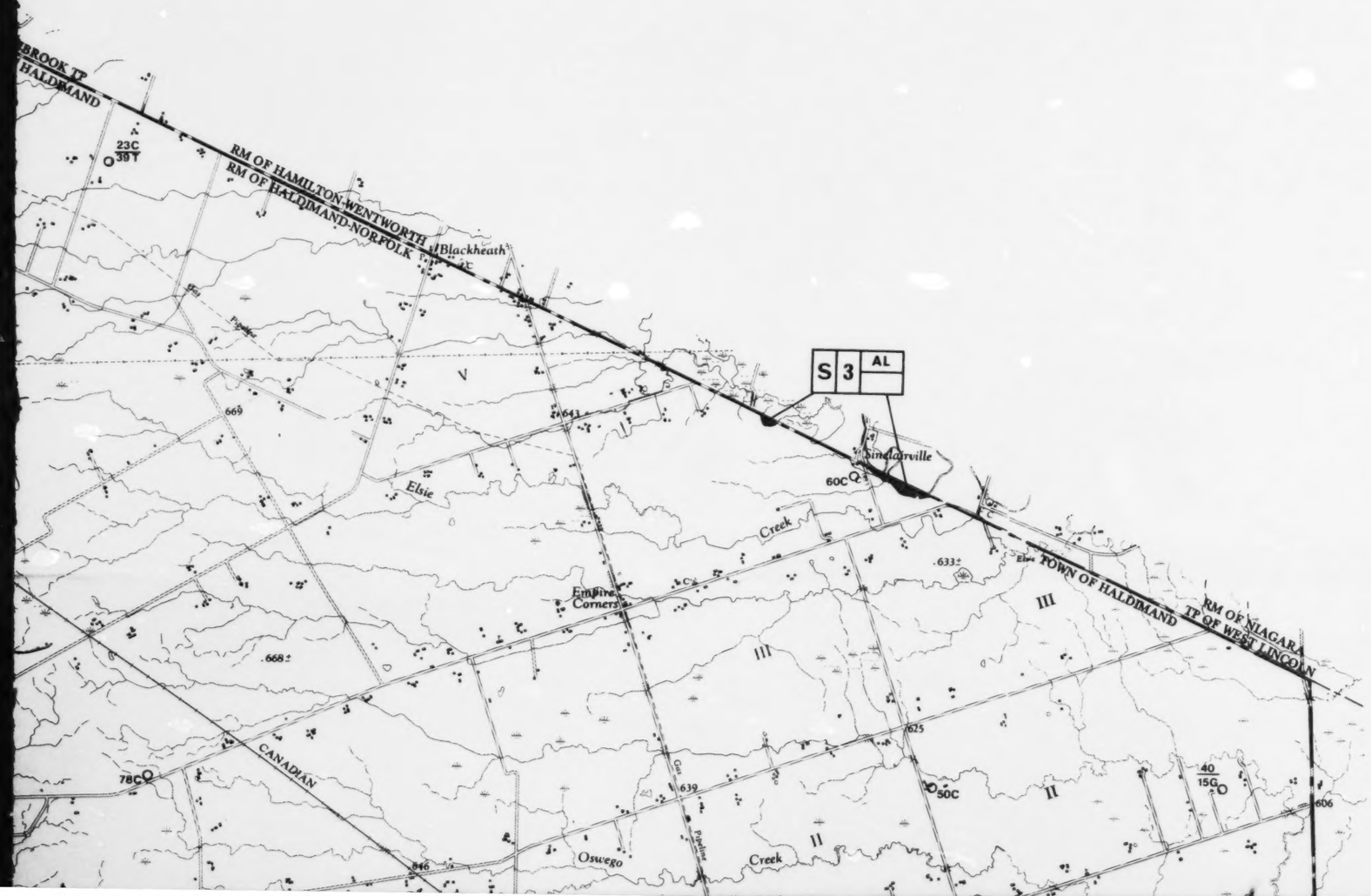
SYMBOLS

(Some symbols may not apply to this map.)

Geological and aggregate thickness boundary. Shading indicates deposit area.

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

Municipal boundary.



SIX NATIONS
Beavers Corner
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RM OF HALDIMAND-NORFOLK
TUSCARORA TP
TOWN OF HALDIMAND
McKENZIE
BOSTON
CREEK
Willow Grove Sta
Willow Grove
Tailings
Gypsum Plant Tailings
Poultry Farm
Hall
Rogers Creek
Orchard
Cranston
Mount Healy
Dufferin
Lythmore
Clanbrassil
York
CANADIAN
MICHIGAN CENTRAL
Water Works
Sawmill
Auto Wrecker
Cayuga
Dump
SIX NATIONS INDIAN RESERVE 40
NEW CREDIT INDIAN RESERVE
Hagersville
Cultural Constraint Boundary
Quarry
Gravel Pit
Crushing Plant
Tanks
Sewage Plant
Sports Track
Park
Tunnel
Water
Chy
Pumping Sta
Town Limits
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Dam
Trans
Creek
Orchard
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BM 684
BM 619
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37C 35T
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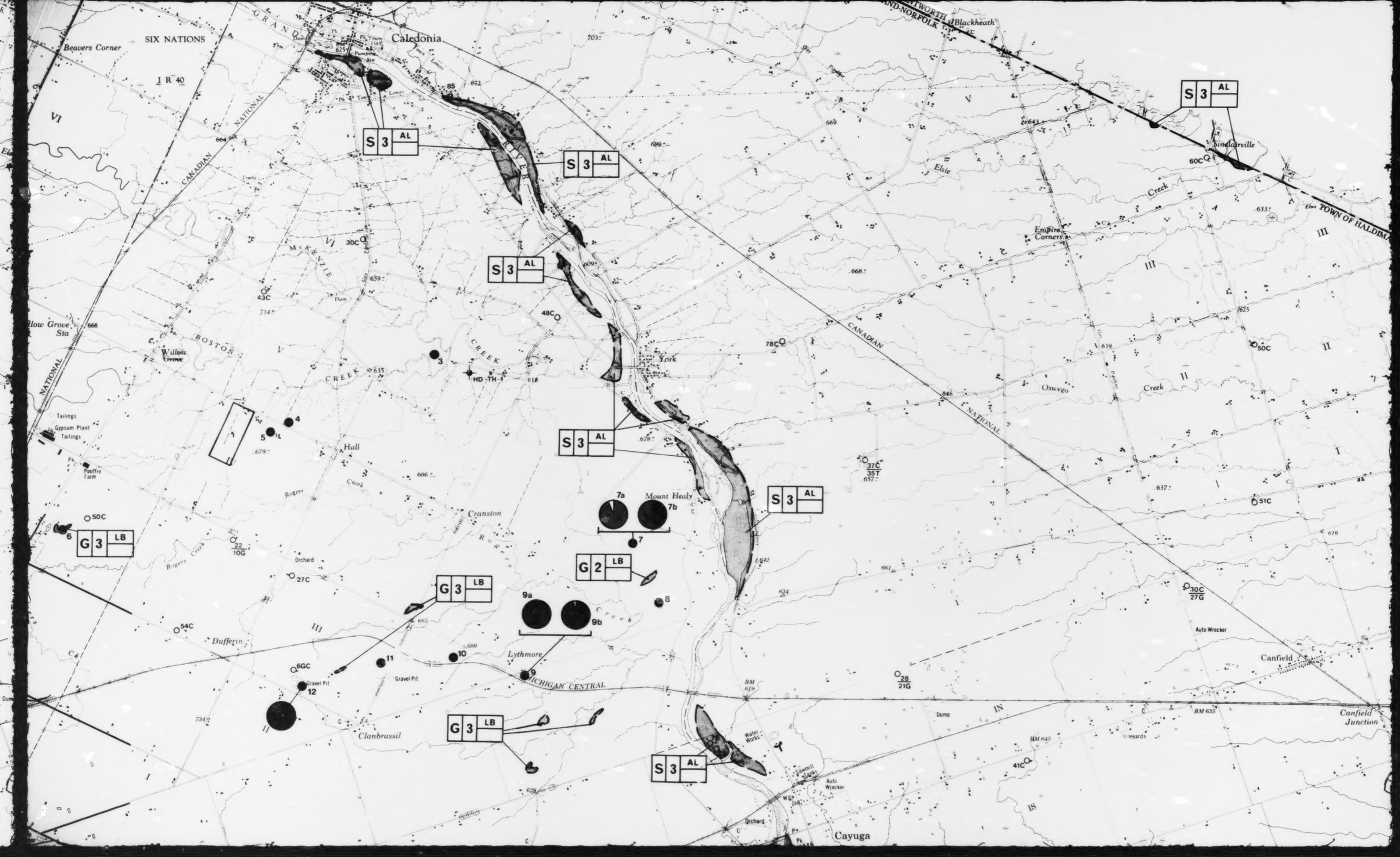
Caledonia
SIX NATIONS
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Sinclairville
TOWN OF HALDIM
Empire Corners
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Creek
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GRAND RIVER
McKENZIE
BOSTON CREEK
Willow Grove
Yellow Grove Sta
Tailings
Gypsum Plant Tailings
Poultry Farm
Hall
Rogers Creek
Cranston
Orchard
Mount Healy
Dufferin
Lythmore
Clanbrassil
Gravel Pit
York
Oswego
Creek
Auto Wrecker
Canfield
Canfield Junction
Vineyards
Dump
Water Works
Sawmill Lapks
Cayuga
MICHIGAN CENTRAL
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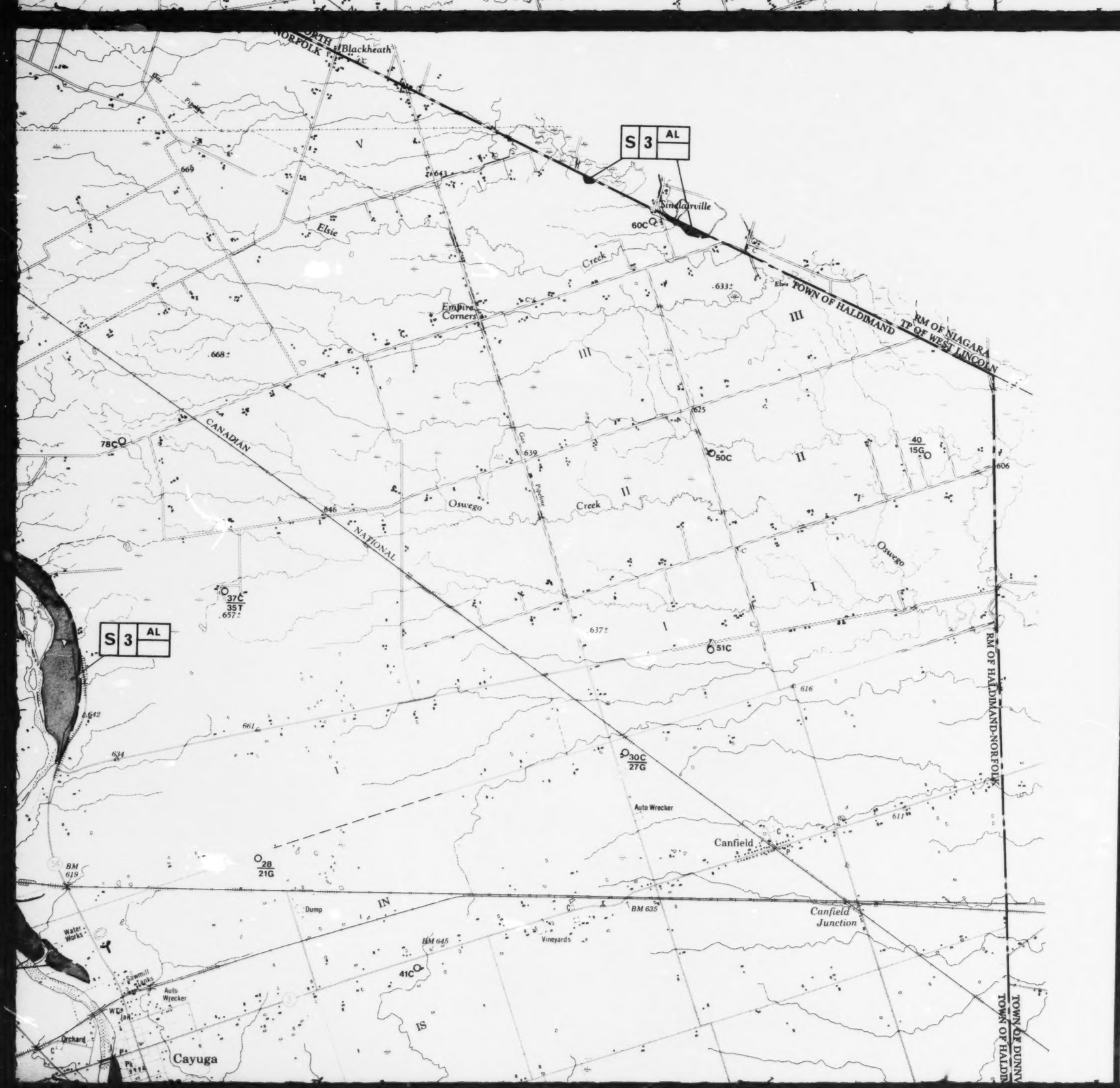
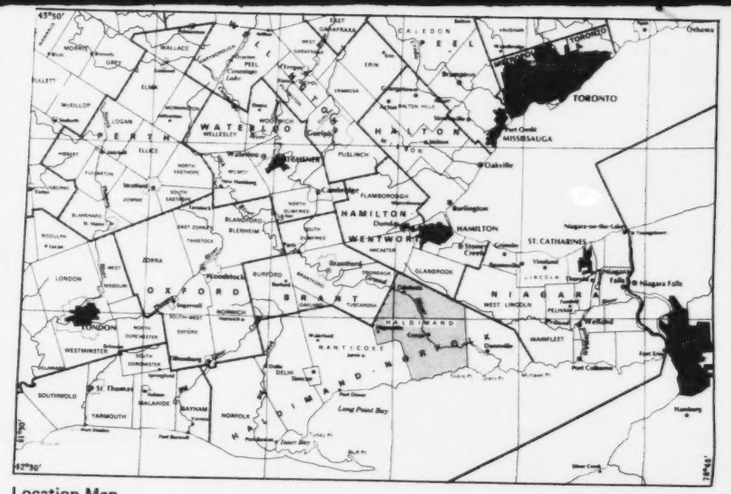




Location Map

Scale: 1:800,000

SYMBOLS

(Some symbols may not apply to this map.)

Geological and aggregate thickness boundary. Shading indicates deposit area.

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

Municipal boundary.

2 — Licenced property boundary; Property number: see Table 2.

3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

HD-TH-2 — Selected test hole location; Identification number: see Table 7.

6 / 23 G — Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).

G 1 IC / C-O — Deposit Symbol: see below.

Texture symbol: see below; see Figures 2 to 6.

HD SS 1 — Selected sample site; Identification number: see Figure 6.

DEPOSIT SYMBOL

Gravel Content — G 1 IC / C-O — Geological Type

Thickness Class — Quality Indicator

Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G — Greater than 35% gravel

NEW CREDIT
INDIAN RESERVE

Hagersville

Cultural Constraint Boundary

HALDIMAND-NORFOLK

RM OF HALDIMAND-NORFOLK

RM OF HALDIMAND-NORFOLK

TOWN OF HALDIMAND
CITY OF NANTICOKE

RM OF HALDIMAND

Dufferin

Clanbrasstl

Gill

Nelles Corners

Balmoral

Lythmore

Cayuga

Dunnville

Kohler

Fisherville

Hemlock Creek

Gravel Pit

Gravel Pit

Quarry

Quarry

Quarry

Tunnel

Park

Crushing Plant

Tanks

Sewage Plant

Sports Track

Sports Track

Auto Wrecker

Auto Wrecker

Pumping Station

Plant

Auto Wrecker

Auto Wreckers

Quarries

Orchard

Poultry Farm

Greenhouses

Greenhouses

Cemetery

Park

Water Works

Dump

Campsite

Youth and Agriculture Centre

Airfield (abandoned)

Silos

Orchard

CANADIAN NATIONAL

MICHIGAN CENTRAL

BM 711

BM 684

BM 679

665

684

682

704

656

664

629

599

592

683

12
16G

54C

6GC

11

10

9

9b

8

28
21G

12
11G

10C

2
49G

2
19G

13a

13b

13

12C

14

14a

14b

16C

G 3 LB

S 3 AL

G 3 LB

HD-SS-1

S 4 AL

I

II

III

IV

V

VI

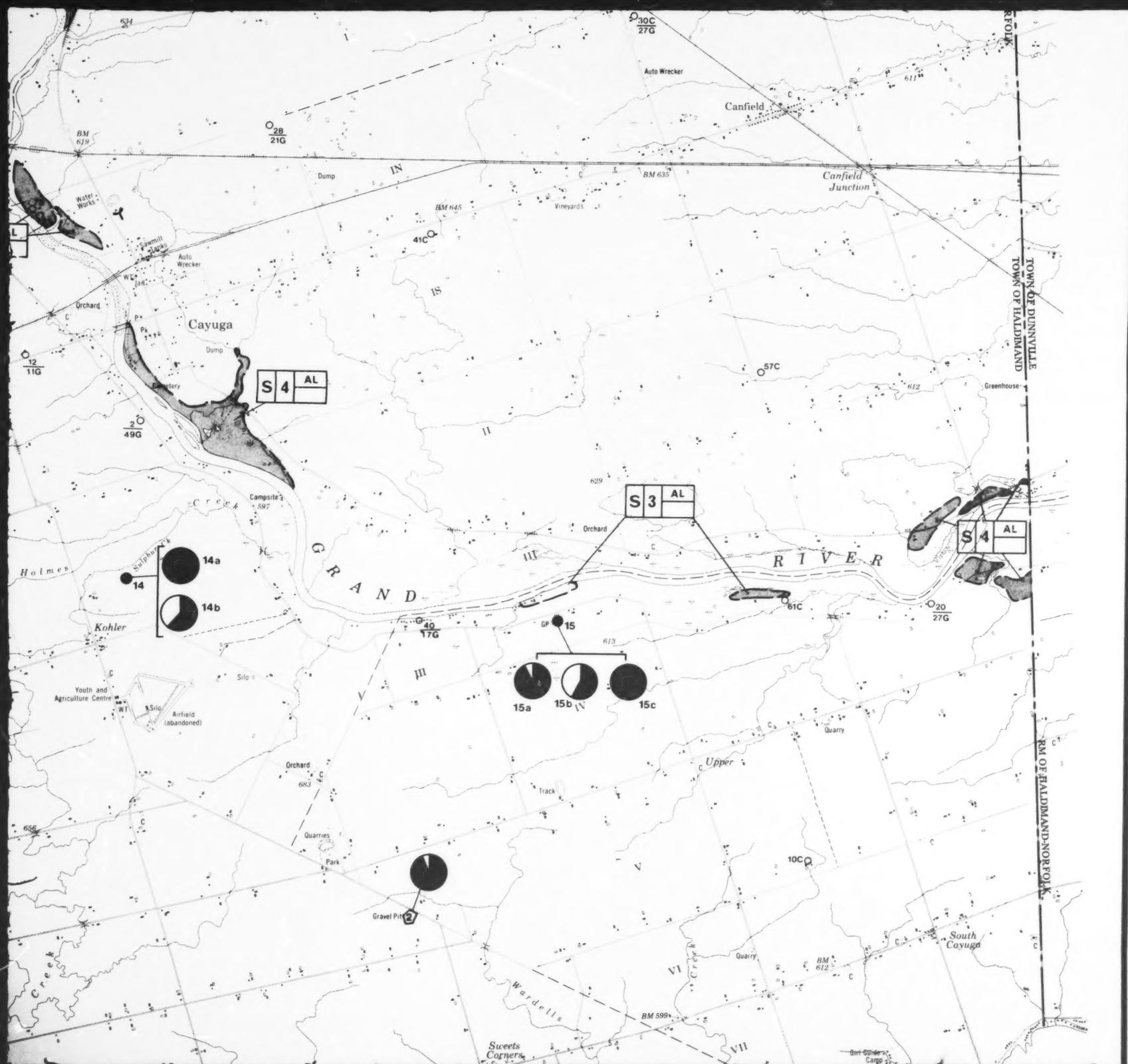
VII

VIII

IX

XI

Clanbrassil
Lythmore
Cayuga
Canfield
Canfield Junction
Decewsville
Nelles Corners
Balmoral
Kohler
Fisherville
Sweets Corners
South Cayuga
Upper
Holmes
Hemlock
Wardells
GRAND RIVER
CANADIAN NATIONAL
MICHIGAN CENTRAL
TOWN OF HALDIMAND
TOWN OF DUNNVILLE
RM OF HALDIMAND-NORFOLK
CITY OF NANTICOKE
Auto Wrecker
Gravel Pit
Dump
Orchard
Vineyards
Greenhouses
Cemetery
Quarries
Quarry
Park
Track
Campsite
Water Works
Sawmill
Poultry Farm
Youth and Agriculture Centre
Airfield (abandoned)
Pumping Station
Sports Track
Dry Lake
Silo
WT
Jail
Creek
BM 619
BM 635
BM 645
BM 612
BM 599
G 3 LB
S 3 AL
S 4 AL
HD-SS-1
6GC
10C
12C
16C
41C
57C
61C
9a
9b
14a
14b
15a
15b
15c

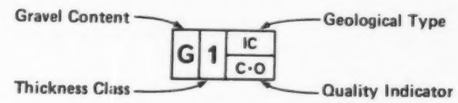


C·O — Deposit symbol: see below.

Texture symbol: see below; see Figures 2 to 6.

HD SS 1 — Selected sample site; Identification number: see Figure 6.

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
3	5-10 (1.5-3)	12,500 - 25,000 (28 000 - 56 000)
4	less than 5 (< 1.5)	less than 12, 500 (< 28 000)

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

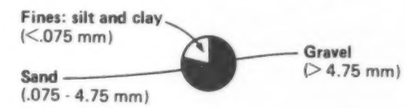
(see Appendix C for descriptions of Geological Types)

Quality Indicator

	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

TEXTURE SYMBOL

(This symbol is used where sample analysis data are available.)



The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Re

N

Pumping Station

Plant

Nelles Corners

G 3 LB

HD-SS-1

2
19G

13a

13b

13

Balmoral

14a

14

14b

Kohler

12C

Orchard

Poultry Farm

Youth and Agriculture Centre

WT

Silo

Airfield (abandoned)

Campsite

TOWN OF HALDIMAND
CITY OF NANTICOKE

RM OF HALDIMAND-NORFOLK

Greenhouses

Fisherville

Park

16C

Greenhouses

Cemetery

Creek

Hemlock

Rainham Centre

BM 622

Orchard

BM 628

Selkirk

Park

602

Pumping Sta

Pool

14C

Silo

Orchard

BM 583

Featherstone

Featherstone Point

Cunningham Reef

Hoover Point

I II III IV V VI VII VIII IX

Gill
Auto Wrecker
Pumping Station
Sports Track
Plant
Nelles Corners
Deceuville
Auto Wreckers
Quarries
2 49G
Campsite
597
Creek
GRAND
RIVER
Orchard
S 3 AL
S 4 AL
61C
20 27G
40 17G
GP 15
15a
15b
15c
613
Quarry
Upper
Track
10C
South Cayuga
BM 612
Gun Club Camp
20S
S 2 WD
Campsite
Picnic Site
5S
9SC
Evans Point
S 3 WD
Evans Creek
Wardells Creek
Sweets Corners
BM 603
Fur Farm
Gates Creek
581
Miller Bay
Featherstone Point
Gravel Pit 2
Quarries
Park
Orchard
683
Youth and Agriculture Centre
Airfield (abandoned)
Silo
Kohler
Sulphur Creek
14
14a
14b
682
Holmes Creek
Campsite
597
G 3 LB
HD-SS-1
13a
13b
13
Balmoral
12C
684
Orchard
Poultry Farm
TOWN OF HALDIMAND CITY OF NANTICOKE
RM OF HALDIMAND-NORFOLK
Fisherville
Park
16C
Greenhouses
Cemetery
Hemlock Creek
Rainham Centre
BM 622
Orchard
BM 638
Selkirk
Park
602
Pumping Stn.
Silo
Pool
14C
Hoover Point
Orchard
BM 588
Cunningham Reef
Featherstone
Religious Camp
Creek
Evans
Creek
Gates
Creek
Miller
Bay
Wardells
Creek
Sweets
Corners
BM
603
Fur
Farm
Campsite
Picnic
Site
5S
9SC
Evans
Point
S 3
WD
S 2
WD
Gun
Club
Camp
20S
BM 599
Quarry
BM
612
South
Cayuga
Track
Upper
Quarry
10C
613
15a
15b
15c
GP
15
40
17G
Orchard
61C
20
27G
S 3
AL
S 4
AL
Campsite
597
Creek
GRAND
RIVER
Auto
Wreckers
Quarries
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49G
Deceuville
Gill
Auto
Wrecker
Pumping
Station
Sports
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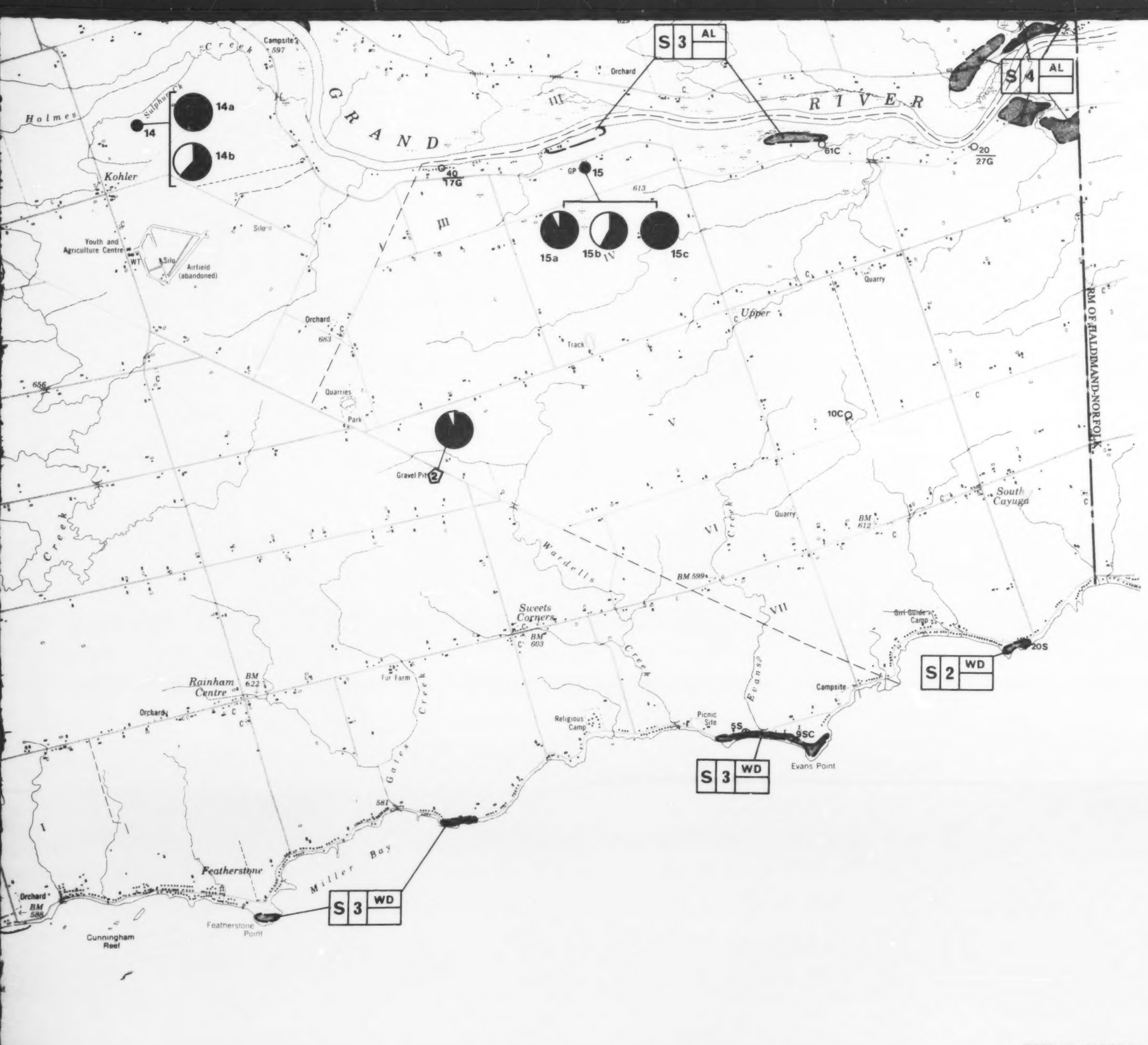
Creek



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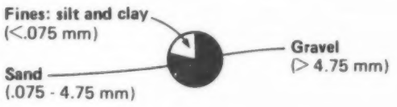

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SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines.

Selected drilled water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: P.J. Barnett, C.K. Girard and A.K. Watt, 1976.
W.R. Cowan, 1972.
B.H. Feenstra, 1974, 1975, in preparation, c.

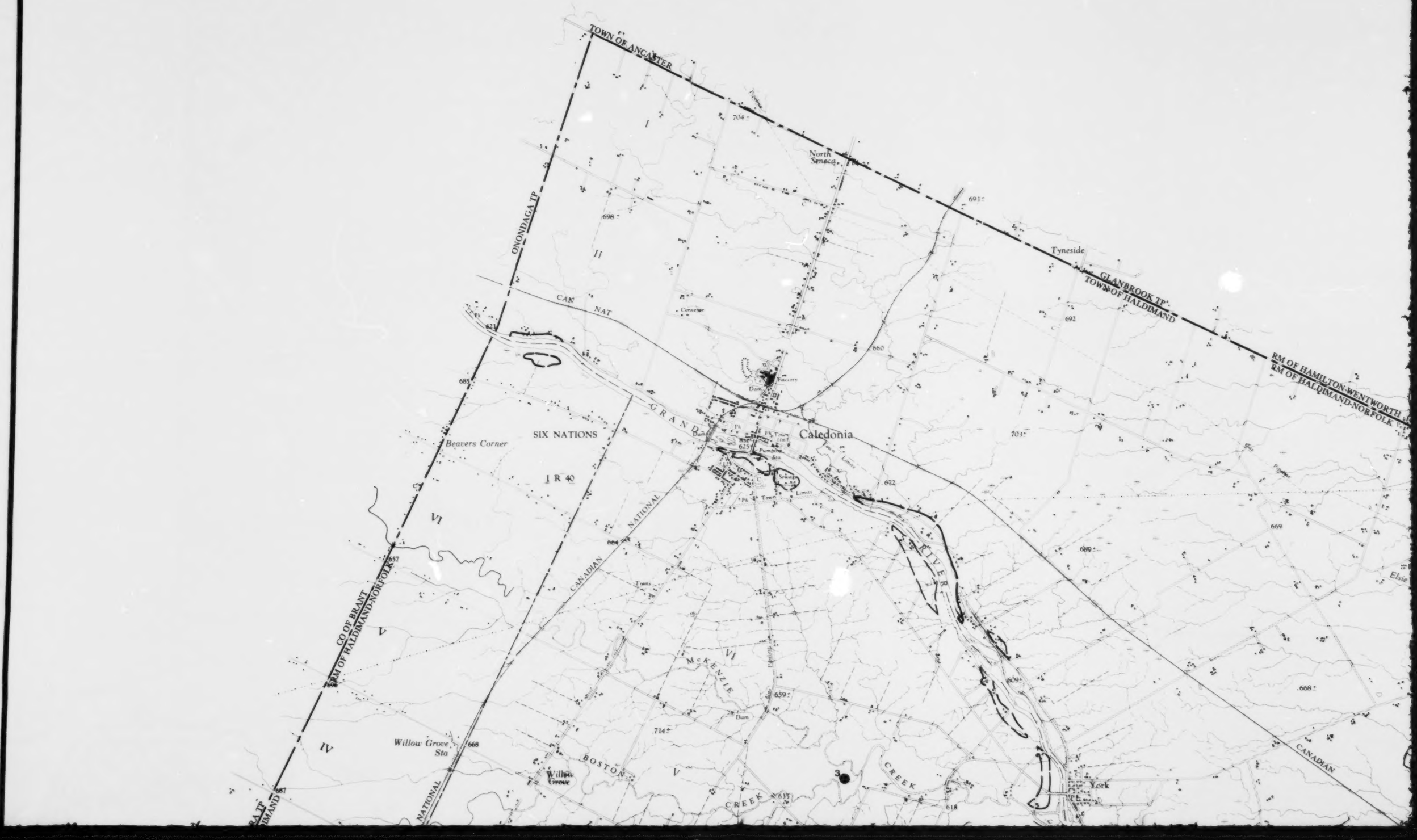
Compilation and Drafting by: Staff of the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 64.

This map is published with the permission of V. G. Milne, Director, Ontario Geological Survey.

Issued 1985.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.


TOWN OF ANCASTER
ONONDAGA TP
North Seneca
Tyneside
GLANBROOK TP
TOWN OF HALDIMAND
RM OF HAMILTON-WENTWORTH
RM OF HALDIMAND-NORFOLK
CAN NAT
Caledonia
Beavers Corner
SIX NATIONS
I R 40
GRAND
RIVER
CANADIAN NATIONAL
CO OF BRANT
RM OF HALDIMAND-NORFOLK
Willow Grove Sta
Willow Grove
BOSTON CREEK
McKENZIE CREEK
York
CANADIAN
Elsie
I
II
III
IV
V
VI

NCASTER

North Seneca

Tyneside

GLANBROOK TP.
TOWN OF HALDIMAND

RM OF HAMILTON-WENTWORTH
RM OF HALDIMAND-NORFOLK

Blackheath

Caledonia

GRAND

RIVER

Elsie Creek

Sinclairville

Empire Corners

TOWN OF HALDIMAND
RM OF NIAGARA
TP OF WEST LINCOLN

McKENZIE CREEK

CANADIAN

York

Oswego Creek

Ministry of
Northern Affairs
and Mines

Ontario

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

THE TOWN OF HALDIMAND

REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 30 L/13, 30 M/4
40 I/16, 40 P/1

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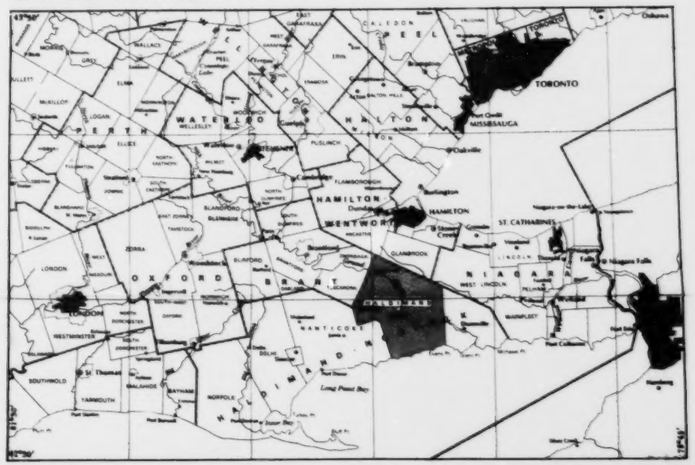

Location Map Scale: 1:800,000

SYMBOLS

(Some symbols may not apply to this map.)

— — — — Geological and aggregate thickness boundary.

SIX NATIONS

Beavers Corner

1 R 40

Caledonia

CANADIAN NATIONAL

CO OF BRANT

TWP OF HALDIMAND-NORFOLK

TUSCARORA TP

TOWN OF HALDIMAND

RIVER

MCKENZIE

BOSTON

CREEK

CANADIAN

Willow Grove Sta

Willow Grove

Tailings

Gypsum Plant Tailings

Poultry Farm

York

Hall

Rogers Creek

Cranston

Mount Healy

SIX NATIONS INDIAN RESERVE 40

NEW CREDIT INDIAN RESERVE

Orchard

Duffegin

Lythmore

MICHIGAN CENTRAL

Gravel Pit

Clanbrassil

Hagersville

Quarry

Crushing Plant

Park

Water

Tanks

Sewage Plant

Sports Track

Cultural Constraint Boundary

Auto Wrecker

Cayuga

Dump

Water Works

Sawmill

Jail

Dam

Pumping Sta

Trans

Orchard

Creek

BM 675

BM 679

BM 711

1

2

3

4

5

6

7

8

9

10

11

12

Pumping Sta.
Limits
672
Town
Limits
669
689±
Elsie
V
643
IV
Sinclairville
Creek
633±
Elsie
TOWN OF HALDIMAND
RM OF NIAGARA
TP OF WEST LINCOLN
Empire Corners
668±
III
III
625
639
606
II
II
Oswego
Creek
Oswego
I
I
637±
RM OF HALDIMAND-NORFOLK
616
611
612
Greenhouse
TOWN OF DUNNVILLE
TOWN OF HALDIMAND
MCKENZIE
Dam
659±
714±
V
CREEK
635
CREEK
618
3
4
5
Hall
679±
686±
Creek
Rogers
Cranston
Orchard
York
678±
CANADIAN NATIONAL
646
Mount Healy
657±
V
7
642
661
634
8
IV
Creek
665
III
689
10
11
12
Gravel Pit
Gravel Pit
Lythmore
9
MICHIGAN CENTRAL
BM 619
Clanbrassil
II
629
C
Water Works
Park
Dump
IN
Auto Wrecker
Auto Wrecker
Canfield
BM 635
Canfield Junction
BM 645
Vineyards
IS
Orchard
Cayuga
Dump
Cemetery
CANADIAN NATIONAL

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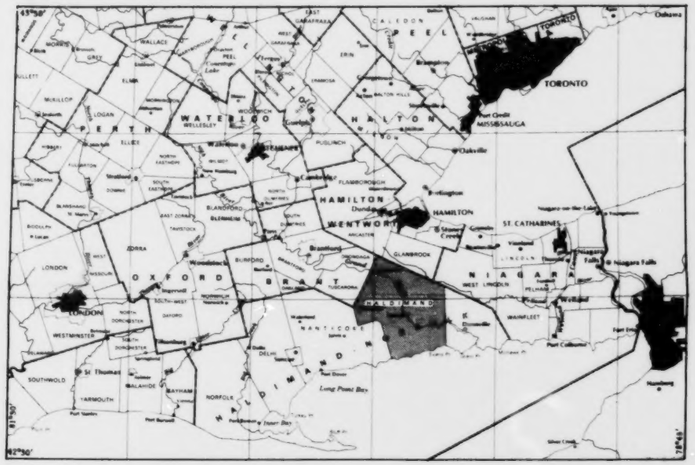

Location Map

Scale: 1:800,000

SYMBOLS

(Some symbols may not apply to this map.)

- Geological and aggregate thickness boundary.
- Buried geological and aggregate thickness boundary.
- Municipal boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- 2 — Licenced property boundary; Property number: see Table 2.
- 3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
  *Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

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Compilation and Drafting by: Staff of the Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Northern Affairs and Mines.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 64.

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SIX NATIONS INDIAN RESERVE 40

NEW CREDIT INDIAN RESERVE

Hagersville

Hagersville

Cultural Constraint Boundary

RM OF HALDIMAND-NORFOLK

RM OF HALDIMAND-NORFOLK

TOWN OF HALDIMAND
CITY OF NANTICOKE

Orchard

Dufferin

Clanbrassil

Lythmore

MICHIGAN CENTRAL

Gravel Pit

Gravel Pit

Gill

Nelles Corners

Balmoral

Orchard

Poultry Farm

Fisherville

Greenhouses

Greenhouses

Cemetery

Deceuville

Auto Wreckers

CANADIAN NATIONAL

Cayuga

Dump

Kohler

Youth and Agriculture Centre

Airfield (abandoned)

Holmes

Sulphur Ck

Creek

Campsite

Orchard

Orchard

Auto Wrecker

Auto Wrecker

Auto Wrecker

Sports Track

Sports Track

Pumping Station

Plant

Tanks

Sewage Plant

Crushing Plant

Quarry

Quarry

Quarry

Tunnel

Park

Park

Park

Park

Dry Lake

Water Works

Sawmill

Dam

Ch

Ch

Ch

Dufferin
Clanbrassil
Lythmore
Gravel Pit
MICHIGAN CENTRAL
Canfield
Canfield Junction
Cayuga
Water Works
Park
Dump
Auto Wrecker
Vineyards
Orchard
CANADIAN NATIONAL
Gill
Auto Wreckers
Deerwsville
Dry Lake
Quarries
Nelles Corners
Pumping Station
Plant
Sports Track
Balmoral
Holmes
Creek
Kohler
Youth and Agriculture Centre
Airfield (abandoned)
Poultry Farm
Fisherville
Cemetery
Greenhouses
Campsite
GRAND RIVER
Upper
South Cayuga
Quarry
Track
Gravel Pit
Greenhouse
TOWN OF HALDIMAND
CITY OF NANTICOKE
TOWN OF DUNNVILLE
RM OF HALDIMAND-NORFOLK
BM 619
BM 635
BM 645
BM 612

Selected sand and gravel resource area; Tertiary significance.

2 — Licenced property boundary; Property number: see Table 2.

● 3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

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Issued 1985.

RM OF HALDIMAND
NORFOLK
Auto Wrecker
Pumping Station
Sports Track
Plant
IX
Nelles Corners
VIII
13
Balmoral
VII
Orchard
Poultry Farm
TOWN OF HALDIMAND
CITY OF NANTICOKE
VI
Greenhouses
Fisherville
Park
Greenhouses
Cemetery
V
IV
664
RM OF HALDIMAND-NORFOLK
III
Creek
Hemlock
II
Selkirk
Park
602
Pumping Sta.
Silo
Pool
Hoover Point
Orchard
BM 588
Cunningham Reef
Featherstone
Featherstone Point
Rainham Centre
BM 622
Orchard
BM 638
I
Creek
Sulphur Ck
Halmes
14
Kohler
Youth and Agriculture Centre
Silo
Airfield (abandoned)
Orchard
683
Campsite
697
Quarr

TOWN OF HALDIMAND
CITY OF NANTICOKE

RM OF HALDIMAND-NORFOLK

Pumping Station
Sports Track
Plant
Nelles Corners
Balmoral
Poultry Farm
Orchard
Greenhouses
Fisherville
Park
Cemetery
Greenhouses
Creek
Hemlock
Selkirk
Park
Pumping Stn
Pool
Silo
Hoover Point
Holmes
Sulphur Ck
Creek
Campsite
Kohler
Youth and Agriculture Centre
WT
Silo
Airfield (abandoned)
Orchard
Quarries
Park
Gravel Pit
Cunningham Reef
Orchard
Rainham Centre
Orchard
Fur Farm
Featherstone
Featherstone Point
Miller Bay
Gates Creek
Sweets Corners
Wardells
Creek
Religious Camp
Picnic Site
Evans Creek
Campsite
Evans Point
Orchard
Track
Quarry
Upper
Quarry
South Cayuga
Girl Guide Camp
GRAND RIVER
RM OF HALDIMAND-NORFOLK

TOWN OF HALDIMAND

GRAND RIVER

Creek

Campsite 597

Sulphur Ck

14

Kohler

Youth and Agriculture Centre

WT

Silo

Airfield (abandoned)

Silos

629

Orchard

GP 15

613

III

IV

V

VI

VII

Quarry

Upper

Track

Orchard 683

Quarries

Park

Gravel Pit 2

Wardells Creek

BM 599

Sweets Corners

BM 603

Rainham Centre

BM 622

Orchards

Fur Farm

Gates Creek

Religious Camp

Picnic Site

Evans Creek

Campsite

Evans Point

South Cayuga

BM 612

Quarry

Girl Guide Camp

RM OF HALDIMAND-NORFOLK

581

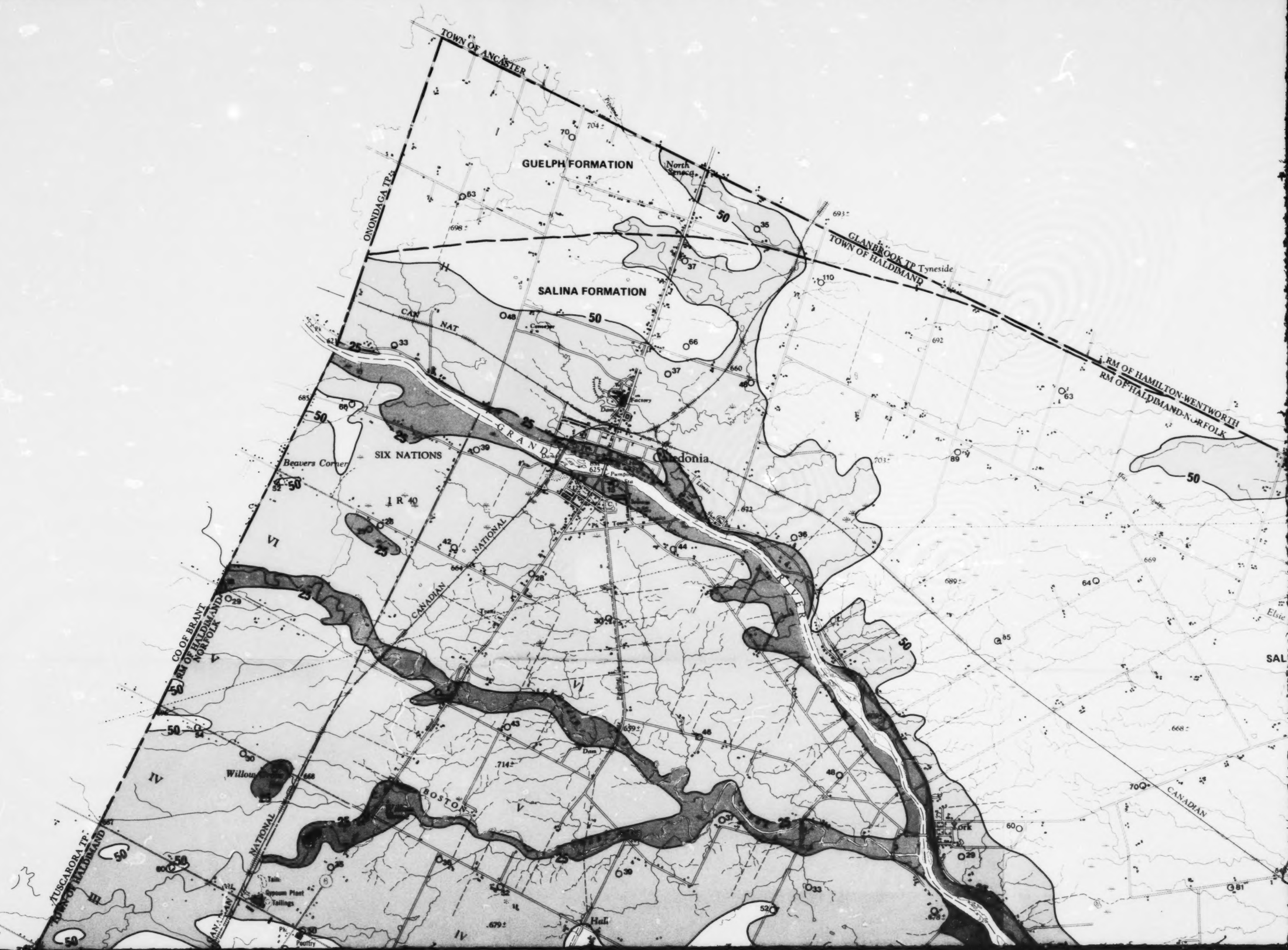
Miller Bay

Featherstone

Featherstone Point

Cunningham Reef

TOWN OF HALDIMAND


TOWN OF ANCASTER
ONONDAGA TP
GUELPH FORMATION
SALINA FORMATION
GLANBROOK TP Tyneside
TOWN OF HALDIMAND
RM OF HAMILTON-WENTWORTH
RM OF HALDIMAND-NORFOLK
CAN NAT
GRAND
Caledonia
Beavers Corner
SIX NATIONS
I R 40
NATIONAL
CANADIAN
CO OF BRANT
RM OF HALDIMAND
NORFOLK
TUSCARORA TP
TOWN OF HALDIMAND
BOSTON
Willow
Gypsum Plant
Tailings
Poultry
Hall
Ork
SAL
I
II
III
IV
V
VI

ANCASTER

GUELPH FORMATION

SALINA FORMATION

SALINA FORMATION

GLANBROOK TP
TOWN OF HALDIMAND

RM OF HAMILTON-WENTWORTH
RM OF HALDIMAND-NORFOLK

RM OF NIAGARA
TP OF WEST LINCOLN
TOWN OF HALDIMAND

Tyneside

Blackheath

Sinclairville

Elsie

Empire Corners

Oswego Creek

Creek

Caledonia

GRAND

CANADIAN

50

RM OF HAMILTON-WENTWORTH
RM OF HALDIMAND-NORFOLK
Blackheath
50
Sinclairville
Elsie
Creek
SALINA FORMATION
Empire Corners
TOWN OF HALDIMAND
RM OF NIAGARA
TP OF WEST LINCOLN
CANADIAN
Oswego
Creek
669
668
639
633
625
606
846

Ministry of Northern Affairs and Mines

Ontario

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

THE TOWN OF HALDIMAND

REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

MAP 3
BEDROCK RESOURCES

Scale 1:50 000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 30 L/13, 30 M/4
40 I/16, 40 P/1

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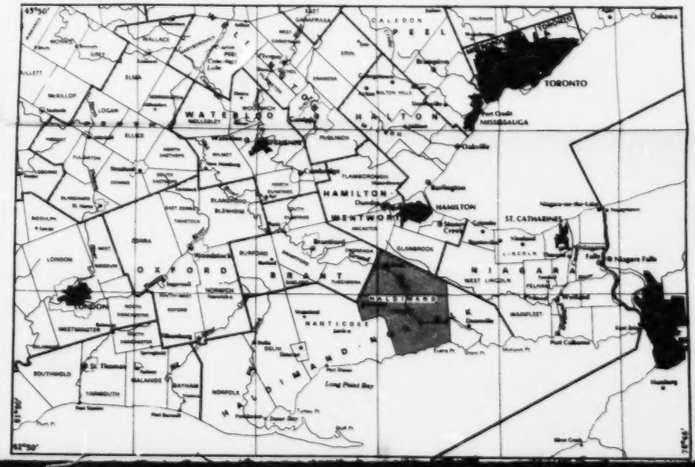

SALINA FORMATION

BERTIE FORMATION

NEW CREDIT INDIAN RESERVE

TUSCARORA TP.

TOWN OF HALDIMAND

CO OF BRANT

CO OF HALDIMAND

NORFOLK

NATIONAL

CANADIAN

MICHIGAN CENTRAL

BOSTON

Willow

Gypsum Plant

Tailings

Poultry Farm

Hall

Rogers Creek

Cranston

Orchard

Duffegin

Lythmore

York

Mount Healy

Quarry

Crushing Plant

Quarries

Sewage

Water Works

Park

Sawmill

Dump

BM 675

BM 711

BM 679

SALINA FORMATION

SALINA FORMATION

BERTIE FORMATION

SALINA FORMATION

SALINA FORMATION

50

50

50

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 30 L/13, 30 M/4
40 I/16, 40 P/1

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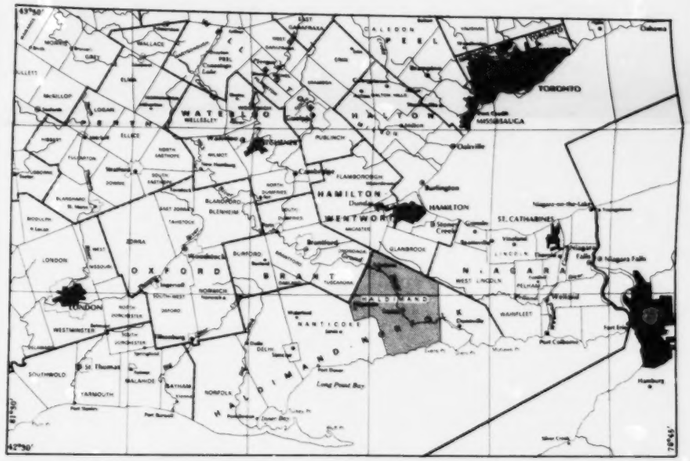

Location Map

Scale: 1:800,000

LEGEND

PALEOZOIC

DEVONIAN

MIDDLE DEVONIAN

DUNDEE FORMATION
Limestone

ONONDAGA FORMATION
Cherty limestone

BOIS BLANC FORMATION
Cherty limestone

ORISKANY FORMATION
Sandstone

BERTIE FORMATION
Dolostone

SILURIAN

UPPER SILURIAN

SALINA FORMATION
Dolostone, shale, gypsum, salt

MIDDLE SILURIAN

GUELPH FORMATION
Dolostone

SYMBOLS

(Some symbols may not apply to this map.)

Geological formation boundary.

Geological formation member boundary.

Formation thickness boundary (see text).

25 Drift thickness contour: 25 foot (8 m) interval.

Municipal boundary.

2 Selected bedrock resource area; Deposit number: see Table 6.

Bedrock exposed or near surface; covered by less than 3 feet (1 m) of overburden: see Table 4.

NEW CREDIT
INDIAN RESERVE

BERTIE FORMATION

BOIS BLANC FORMATION

ONONDAGA FORMATION

BERTIE FORMATION

BOIS BLANC FORMATION

ONONDAGA FORMATION

RM OF HALDIMAND-NORFOLK

CITY OF NANTICOKE

Hagersville

Cayuga

Balmoral

Nelles Corners

Lythmore

Dufferin

Orchard

Cranston

Mount Healy

Kohler

Rogers Creek

MICHIGAN CENTRAL

Greenhouses

Poultry Farm

Youth and Agriculture Centre

Campsite

Cemetery

Dump

Water Works

Park

Auto Wrecker

Pumping Station

Sulphur Creek

BM 675

BM 679

1

2a

2b

2c

BERTIE FORMATION

SALINA FORMATION

BOIS BLANC FORMATION

ONONDAGA FORMATION

BERTIE FORMATION

BOIS BLANC FORMATION

ONONDAGA FORMATION

Cayuga

Canfield

Canfield Junction

Lythmore

Balmoral

Kohler

Nelles Corners

Orchard

Auto Wrecker

Greenhouses

Youth and Agriculture Centre

Campsite

Cemeteries

Dump

Park

Water Works

Sulphur Creek

GRAND RIVER

MICHIGAN CENTRAL

TOWN OF HALDIMAND-NORFOLK

TOWN OF DUNNVILLE

TOWN OF HALDIMAND

RM OF HALDIMAND-NORFOLK

CITY OF NANTICOKE

SALINA FORMATION

BERTIE FORMATION

BOIS BLANC FORMATION

ONONDAGA FORMATION

Cayuga

Canfield

Canfield Junction

Auto Wrecker

Greenhouse

Cemetery

Dump

Orchard

Campsite

Water Works

Park

Youth and Agriculture Centre

Kohler

Sulphur Creek

Upper Trail

GP

TOWN OF HALDIMAND-NORFOLK

TOWN OF DUNNVILLE

TOWN OF HALDIMAND

RM OF HALDIMAND-NORFOLK

QUEENSTON FORMATION
Shale

CHIPPEWA FORMATION
Dolostone

DUNDEE FORMATION
Limestone

DETROIT RIVER GROUP
Cherty limestone

BOIS BLANC FORMATION
Cherty limestone

ORISKANY FORMATION
Sandstone

BERTIE FORMATION
Dolostone

SILURIAN

UPPER SILURIAN

SALINA FORMATION
Dolostone, shale, gypsum, salt

MIDDLE SILURIAN

GUELPH FORMATION
Dolostone

SYMBOLS

(Some symbols may not apply to this map.)

Geological formation boundary.

Geological formation member boundary.

Formation thickness boundary (see text).

25 — Drift thickness contour: 25 foot (8 m) interval.

Municipal boundary.

2 — Selected bedrock resource area; Deposit number: see Table 6.

Bedrock exposed or near surface; covered by less than 3 feet (1 m) of overburden: see Table 4.

Bedrock covered by 3 to 25 feet (1 to 8 m) of overburden: see Table 4.

Bedrock covered by 25 to 50 feet (8 to 15 m) of overburden: see Table 4.

x — Isolated bedrock outcrop.

Q2 — Licenced quarry boundary; Property number: see Table 5.

Q3 — Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.

28 — Selected drilled waterwell location; reported depth to bedrock (in feet).

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Selected drilled water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

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P.F. Karrow and D.J. Sprague, 1975.
B.A. Liberty, B.H. Feenstra and P.G. Telford, 1976.
P.G. Telford, 1979.
P.G Telford and A.P. Hamblin, 1980.
P.G. Telford and G.A. Tarrant, 1975.

ONONDAGA FORMATION
DUNDEE FORMATION
DUNDEE FORMATION
DUNDEE FORMATION AS
ONONDAGA FORMATIO
TOWN OF HALDIMAND
CITY OF NANTICOKE
RM OF HALDIMAND-NORFOLK
Balmoral
Nelles Corners
Pumping Station
Fishgrvill
Greenhouses
Selkirk
Hemlock
Sulphur Cr
Youth and Agriculture Centre
Cunningham Reef
Featherstone Point
Hoover Point
Miller
Campsite
Park
Cemetery
25
50
VII
VI
V
IV
III
IX

BOIS BLANC FORMATION

ONONDAGA FORMATION

BERTIE FORMATION

DUNDEE FORMATION

RM OF HALDIMAND-NORFOLK

CITY OF NANTICOKE

TOWN OF HALDIMAND

Nelles Corners

Balmoral

Kohler

Youth and Agriculture Centre

Sulphur Creek

Campsite

Orchard

Poultry Farm

Greenhouses

Cemetery

Fisherville

Hemlock

Sweets Corners

Upper Cayuga

South Cayuga

Evans Point

Selkirk Park

Miller Bay

Cunningham Reef

Feathershore Point

Hoover Point

Track

Orchard Pit

Fur Farm

Picnic Area

Golf Course

Campsite

Pumping Station

Youth and Agriculture Centre

Airfield

Cemetery

Orchard

Poultry Farm

Greenhouses

Fisherville

Sulphur Creek

Campsite

Track

Orchard Pit

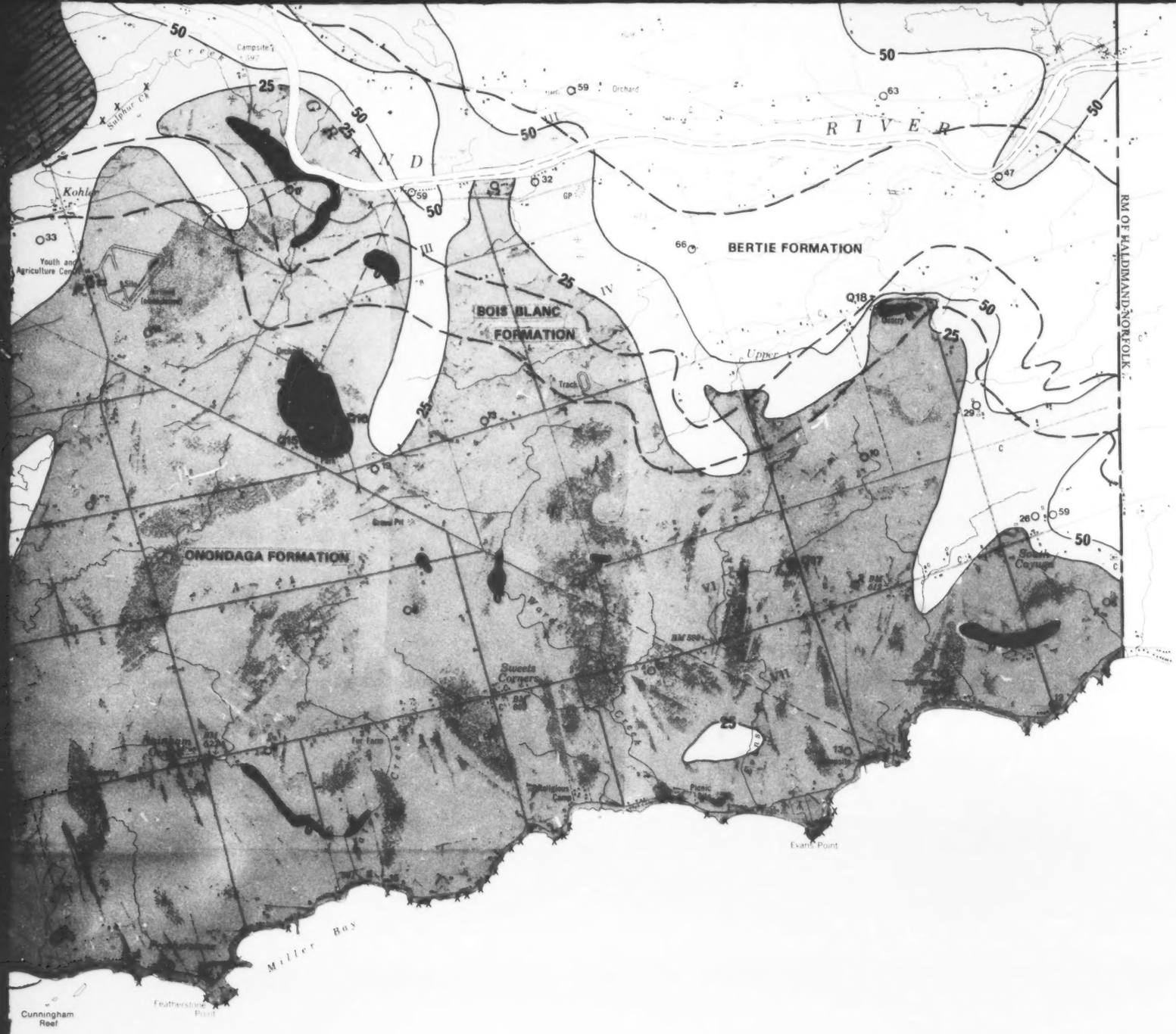
Fur Farm

Picnic Area

Golf Course

Campsite

Pumping Station



TOWN OF HALDIMAND

x Isolated bedrock outcrop.

Q2 Licenced quarry boundary; Property number: see Table 5.

● Q3 Unlicenced quarry*; Property number: see Table 5.
*Abandoned quarry or wayside quarry operating on demand under authority of a permit.

○ 28 Selected drilled waterwell location; reported depth to bedrock (in feet).

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Selected drilled water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

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P.F. Karrow and D.J. Sprague, 1975.
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P.G. Telford, 1979.
P.G Telford and A.P. Hamblin, 1980.
P.G. Telford and G.A. Tarrant, 1975.

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